THE HANDICAP OF DEAFNESS

IRENE R. EWING

AND

ALEX. W. G. EWING


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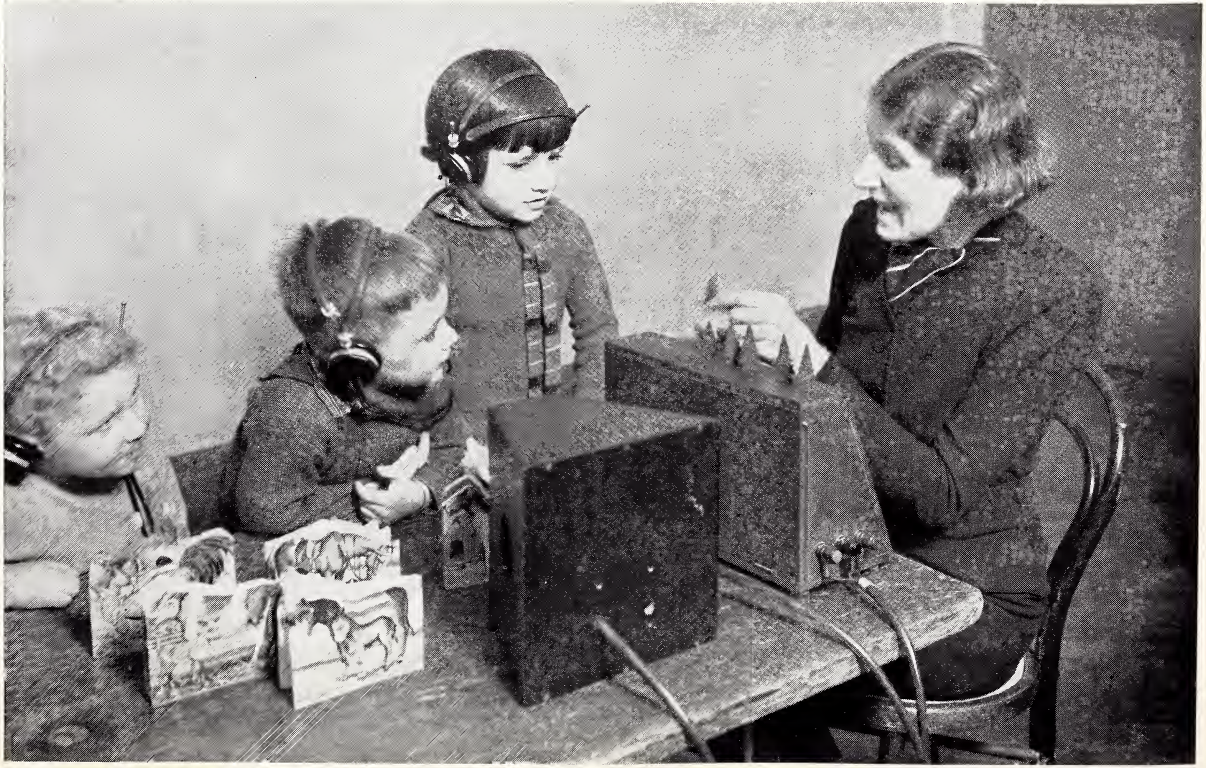

Hearing and lipreading.

THE HANDICAP OF DEAFNESS

BY

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WITH ILLUSTRATIONS

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In my house dwells only quietness.
No humming of bees at noontide, nor the drowsy rustle
Of falling leaves,
No delicate music of flutes or violins
Can steal across its silence.
The melody of voices, the sweet cadence
Of gentle words, the sudden joy of laughter
I do not know.
I have not heard the whisper of the flame,
Nor the soft rush of water. No footfall
Can pierce the woven silence. In my house
No birds will sing.

NORA WILKINSON

PREFACE

This book is dedicated to the memory of Sir James E. Jones of Rochdale and to that of his son, Ellis Llwyd Jones, in remembrance of whom the Department of Education of the Deaf was founded in the University of Manchester.

Sir James Jones, by his foresight and generosity, created a unique opportunity for the study of methods of teaching the deaf and of alleviating incurable deafness. There was no aspect of educational or social work for the deaf in which he did not take the deepest and most active interest. His daughters, Miss Enid and Miss Amy Jones, have continued their father's tradition. The opening of a clinic in the department would have been impossible without their generous support.

Close co-operation between the department and the Royal Residential Schools for the Deaf, Manchester, of which Sir James Jones was chairman for twenty years, was an indispensable feature of his plan.

The writers are glad to have the opportunity of expressing their deep indebtedness to the committee of the schools ; to the late Mr. William Nelson, former headmaster ; the present headmaster, Mr. John Spalding ; the staff and the children for their constant help given freely and graciously over many years.

The writers also wish to thank the trustees of the late Lord Leverhulme, the Medical Research Council and the Royal Society, for financial help, without which the investigations made in the department would not have been possible.

These investigations have been carried out by a team of which Dr. T. S. Littler, Lecturer in Acoustics in the department, has been a vital member. It is difficult to do justice to the outstanding service he has rendered to the deaf by designing highly efficient hearing-aids, and to the essential part

he has played in all experimental work appertaining to their use. The writers owe him a great personal debt.

They also thank the Misses Gladys Conway, Hilda Goldsack and Agnes Adams for suggestions and helpful criticisms of the text. Every member of the staff of the Department of Education of the Deaf has shared in the work recorded in this book.

The photographs of children being taught by the hearing-lipreading method were taken in the Royal Residential Schools for the Deaf, Manchester, and are reproduced by the courtesy of the committee and headmaster.

Irene R. Ewing.
Alex. W. G. Ewing.

The University,
Manchester, 1938.

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CHAPTER I.

PROBLEMS OF DEAFNESS.

This book has been written in answer to many requests : its aim is practical. It is intended to be a working source of information to all who are unfortunate enough to suffer from defects of hearing, as well as to professional workers who serve the deaf. Amongst these latter must be numbered those responsible for advising patients diagnosed as suffering from chronic or progressive deafness : those upon whom it falls to detect deafness in children, to decide the place and manner of their education : those who teach the deaf : those who organise and carry on welfare work among the deaf, the hard-of-hearing and the deaf-blind.

How devoted and how strenuous is the service given by these workers, only those who see it for themselves can know. It rarely attracts the limelight of public interest. Its results are of incalculable value, but they are as a rule too slowly obtained to be sensational or to rank as " news." In spite, however, of all that is being done for the deaf by the State and by independent and voluntary agencies, the first problem which must be faced is, bluntly speaking, that the deaf person meets all too often with very little sympathy or help.

The gropings of a blind man no longer make a comic turn upon the stage. Apparently they did some three centuries ago when Shakespeare wrote his " Merchant of Venice." The time has gone past when visible suffering can raise a laugh. Yet the mental and therefore invisible struggles of the man who is deaf or the woman who sits lonely among her chattering family because she cannot catch what they say, are still considered humorous.

It is, above all, on behalf of deaf people and deaf children that this book is written. They bear the brunt. We are not concerned here with sufferers from temporary forms of deafness, amenable to medical or operative treatment, but with those whose hearing has been defective from birth, or whose

deafness has been diagnosed as chronic. They must endure deafness to the end of their days, without respite and without relief. Probably no one but the patient himself can fully understand the mental strain imposed by defective hearing. Even his nearest relatives may fall into the delusion that he could hear what they say so much better if he would only take the trouble to attend more carefully. They may come to think that he gives his friends unnecessary trouble by a certain mental laziness.

The results of experimental tests quoted in later chapters show the injustice and falseness of such conclusions. In proportion to the severity of their deafness most patients are forced into a degree of alertness and effort greater than that of people with normal hearing. They are, as it were, forever at the end of a very bad telephone line. The most casual remark comes to them in an incomplete, often in a distorted, form. They struggle to keep up with a general conversation by qualities akin to those of the detective, piecing together imperfect clues, half a phrase here and another there, to gain somehow or other the sense of what is said.

In a certain proportion of instances such an unending struggle becomes beyond the capacity of the patient to sustain. In whole or in part he gives it up and becomes more or less isolated, acutely unhappy or apathetic. More will be said on this subject later. But it is clearly wrong to say that such a patient is lazy or inattentive. At the onset of deafness every sufferer makes an effort to hold his normal place in life. Despair and a relaxation of the struggle only begin as the result of persistent failure.

The study of deafness by modern experimental methods is bringing about an entirely new conception of its nature. Probably the most important advance is in our knowledge about defects of hearing which do not amount to total loss. In this field the gravity of the handicap, its stunting and withering effect on mental development and mental well-being in children and probably also in adults is being shown as never before.

It has long been generally realised that children totally deaf from birth or infancy cannot learn to talk by natural means. They are taught to speak by laborious and artificial methods, and their whole education, although in many instances successful to an amazing degree, is based on artificial processes. To-day it is plain that there is no such thing as

a clear-cut border-line between the " deaf and dumb " and that large section of the population of every age which suffers from defective hearing. The effects of deafness are to be seen in the little untaught deaf and dumb child, whose only method of communication with his parents is often crude gesture, and who knows nothing outside his own tiny world of sense experience. But they are also to be found in a lesser, though still serious degree, amongst patients who range from severely deaf to what they themselves describe as hard-of-hearing.

These effects may be summarised under two main heads :

First, interference with free conversation under average normal conditions. For the boy or girl this affects ability to progress normally at school. For the adult it threatens the power to earn a livelihood and the capacity to fill normally and efficiently the part of a parent, a citizen, a member of any organisation. How far, for instance, can a man who cannot hear what is said without conscious effort share the confidence of his children, his fellow-citizens or the members of his club ?

Secondly, there is the effect of deafness on the patient's own speech. This involves a series of problems. Speech has been described by a great neurologist, Sir Henry Head, as a " march of events, acquired step by step in the life of the individual." [1] It is true that the earlier years of life are those in which speech development is most rapid. The normal child of five speaks with fluency and with a considerable vocabulary. He has not, however, finished learning to talk. That is a process which continues without stop so long as life lasts. New phrases and words are heard from time to time. Not all of them are adopted and used, but even in old age the listener with normal hearing probably makes some of them his own.

Besides this the meaning of known words and expressions is constantly being enriched by further experience. The word " Mississippi," after the inundations of 1937, acquired new meaning in the minds of those who heard an eye-witness broadcast a description of burst banks and flooded towns. Still more did its meaning alter in the minds of those made homeless by the floods.

Defects of hearing, even when they occur in adult life,

[1] Head, Henry, 1926, *Aphasia and Kindred Disorders of Speech*, p. 474. Cambridge University Press.

are often followed by deterioration in speech. Pronunciation becomes less distinct ; sometimes speech is wholly unintelligible to strangers. The voice often ceases to be normally produced, becoming harsh or high-pitched or almost inaudible. The sufferer is no longer able to adjust the loudness of his voice to the conditions of quietness or noise in which he is speaking.

Those difficulties are problems in themselves which to-day are at least in part soluble. They are mentioned at this point as evidence of a graver question. If some degree of deafness can cause such deterioration in the more physical and mechanical aspects of speech, is there an analogous arrest or even deterioration in the life of the mind ? The word " analogous " in the last sentence needs to be emphasised. The patients with the least good speech may not necessarily be those whose mental life is most affected by deafness. It has long been observed that the risk of speech deterioration is greatest in the case of inner ear or nerve deafness, and that it is not wholly dependent on the power to hear the speech of others. This subject is discussed more fully in Chapter IV. The question at the moment is whether a trouble which so markedly affects a patient's talking does not also injure his thinking, although not necessarily in the same degree.

The nature of the problem was forcibly illustrated by a question put by a friend. He asked whether without the help of a first-class hearing-aid or of proficiency in lipreading it would be possible for a scientific worker who had become severely deaf to maintain the highest level of efficiency. Would reading alone give him the essential contact with other workers ? The friend, who spoke with authority, thought not. He believed that no amount of study or hard work could compensate for the lack of direct personal intercourse and comparison of notes in conversation. " It's not so much what you say as the way you say it " is an apt statement of a profound truth.

What indeed are the psychological effects of deafness ? Clearly this is a vital question and one which only long investigation can hope to answer. How much did deafness really bend or mould the genius of Beethoven ? And apart from the rare and great genius, how much does it dominate the lives of thousands of ordinary folk ? That it can be a destroying influence is only too obvious, but in what ways, and when incurable, how far can it be alleviated ?

We need a definition of the word deafness itself. Here popular opinion lags far behind scientific knowledge. We must recognise that reluctance to admit "hardness of hearing" is very prevalent. This may be natural but it is often evil in its consequences.

During the period October, 1934, to September, 1937, tests of hearing were made of 1037 adults or boys and girls of school age, who have attended either in the clinic attached to the Department of Education of the Deaf at Manchester University or as private patients. The results of these tests will be analysed later.

Two points, however, are very clear at the outset: first, that numerous patients, although advised many years ago that they could expect no further benefit from medical treatment, had taken no decided steps to seek alleviation by other means. Many had waited until they were almost isolated from social life before giving serious consideration to the use of a hearing-aid or to learning to lipread.

Secondly, the figures show a preponderance of very deaf people among these patients. Yet in many instances there must have been a time when the hearing loss was much less great, for we are not at present discussing the born deaf or those deaf from childhood. It is part of the purpose of this book to emphasise the proved fact that in cases of progressive and irremediable deafness the help of lipreading and, when possible, of a hearing-aid is invaluable at early stages before deafness has become severe, and before social isolation and speech defects threaten.

Detailed statistics about the extent of deafness among the general population, based on large-scale testing of enough representative groups of individuals, do not as yet exist. An authoritative modern estimate places the number of persons in England and Wales with defective hearing as high as 6½ millions, or about 16 per cent. of the population. The same writer considers that about 150,000 persons would be eligible to benefit from a Deaf Persons' Act.[1]

Audiometer tests of the hearing of numbers of school children were begun in America in 1924-5 [2] and in Great

[1] Wells, A. G., 1937, "An Estimate of the Incidence of Defective Hearing in England and Wales," *British Medical Journal*, July 3rd, pp. 18-20.

[2] Day, H. E., Fusfeld, J. S., and Pintner, R., 1928, *A Survey of American Schools for the Deaf*. National Research Council.

Britain in 1928.[1, 2] To-day the gramophone audiometer is being increasingly adopted by school medical services as a means of detecting deafness amongst children in all types of schools. As regards adults, it is only through the bringing about of a different attitude towards this trouble that fuller statistics can be obtained. Any tendency that may prevail to try to ignore the existence of deafness in oneself or in one's dependents is unworthy of the courageous realism of our times and can only hamper progress.

It is greatly to be hoped that as facilities become available for the measurement of hearing, it will be more and more realised that it is good policy not only for the severely deaf but also for the general public to have their hearing tested. It is only during the post-war period that norms or standards of efficiency of hearing have been set up, and the effects, on mental and speech development, of various forms of defective hearing traced out in detail. We know now that it is just as necessary to be able to hear efficiently as it is to have fresh air, nourishment, warmth and housing.

The Report on the Health of the Army published in 1936 showed that diseases of the middle ear (including deafness) accounted for the rejection on medical examination of more would-be recruits than any other single cause. For 1933-4 the ratio per 1000 of rejections under this head was 47·71, for 1932-3 it was 51·33. These men and boys are not perhaps in all respects a typical cross-section of the population as a whole, but tests of any group of older persons would probably give a much higher ratio of ear disease and deafness. Of the urgency of greater national attention to deafness, however, the evidence quoted in later chapters of this book may be left to speak for itself.

Two chief sources of information have been used by the writers.

There is first of all a growing body of data about deafness gained by modern experimental methods. Broadcasting, the long-distance telephone, and high quality sound recording have become possible and are the outward and visible signs of

[1] Crowden, G. P., and Gale, A. H., 1930, *Medical Officer*, Sept. 13th, p. 113.

[2] Ewing, A. W. G., 1930, *Aphasia in Children*, p. 42. Oxford Medical Publications.

a great leap forward in scientific method and knowledge about sound, about electricity, and especially about the kind of sound used in human speech.

This leap forward has given us new and vastly more efficient apparatus for measuring speech and for testing hearing. It has given us new hearing-aids which are as great an improvement on those of ten years ago as a modern broadcast heard through the most up-to-date radiogram is an improvement on the first experimental broadcasts listened to through headphones and a crystal set.

The importance of all this development, and its direct and indirect results, to sufferers from deafness is still far from being generally recognised. The writers hope that in the succeeding pages they have made clear to the non-technical reader the procedure by which it is now possible for a patient to obtain what is for him the most efficient hearing-aid.

There is no longer any need for a patient to be in the position of one who entered the clinic carrying in a box nine hearing-aids, all of which, she said, she had found useless. This actually happened. Other patients have come to our clinic with a similar experience to report. It seems that, naturally enough, they have snatched at any possible hope of help and often have sacrificed much to buy so-called hearing-aids, unsuitable to them, especially when driven by the fear that without hearing they cannot earn their living. Such raising and dashing of pitiful human hopes can now be avoided. It is very urgent that, for this reason alone, all the information which now exists should be published in a form suitable for the general reader.

During recent years hearing-aid apparatus has been increasingly used in schools for the deaf and partially deaf in Britain and America. There were numerous earlier pioneer efforts, but the movement received its present impetus from the discovery that only a small number of children are totally deaf. Even children who come to school dumb on account of deafness may yet have useful " residual " hearing.[1, 2, 3]

[1] Ewing, A. W. G., 1930, *Aphasia in Children.* Oxford Medical Publications.

[2] Ewing, A. W. G., Ewing, I. R., and Littler, T. S., 1936, " The Use of Hearing Aids," *Medical Research Council Report*, H.M. Stationery Office.

[3] Kerridge, P. M. T., 1937, " Hearing and Speech in Deaf Children," *Medical Research Council Report*, H.M. Stationery Office.

This is another way of saying that although too deaf to hear ordinary conversation they are able, in a degree very valuable to their education, to hear the human voice when made louder by artificial means.

It was not until audiometers having a wide range of pitch and loudness were designed and constructed that accurate and detailed knowledge about residual hearing could exist. Now when such radical changes in principle and method are taking place it is imperative that those responsible for the education of partially and severely deaf children should have ready access to the essential technical knowledge. It is urgent that school medical officers and teachers should be able to estimate from the results of audiometer and standardised intelligibility tests the degree of accuracy with which each boy or girl under their charge

(i) can follow what is said with the unaided ear, and
(ii) can be made to hear speech with the best hearing-aid apparatus available.

The relative importance of proficiency in lipreading to each pupil, in the classroom and out of school, requires to be known. For lipreading is necessary to all who suffer from defects of hearing.

The stark fact stands, at once cheering and depressing, that through the use of suitably designed classroom hearing-aids, many children with considerable, or severe, deafness can hear speech to an extent which is quite unattainable as yet by means of individual portable aids.[1]

The efficiency of the apparatus built on generous lines for the schoolroom is inevitably greater than that of the portable hearing-aid. The conditions of good studio broadcasting can be given. This is beginning to be realised by far-sighted school authorities. At the Royal Schools for the Deaf, Manchester, a special building designed for this type of work has now been in use for some time.

The erection of new buildings of a special character, and their equipment with apparatus, necessarily involves much expense. In a period of transition there is considerable risk that the existence of important information may not be fully

[1] Ewing, A. W. G., Ewing, I. R., and Littler, T. S., 1936, *The Use of Hearing Aids*, pp. 30 and 38.

appreciated, and that equipment may be bought which cannot fulfil essential requirements or which is already obsolete. The writers hope that by correlating in the present book the results of six or seven years of daily experience in the use of electrical aids for teaching the deaf, with data obtained in the laboratory during the same period, they may help to prevent needless disappointment.

Much can be done to-day to alleviate deafness and to minimise its ill-effects in both adult life and childhood. The means of alleviation are not however wholly due to modern experiment. It would be more accurate to say that modern experiment is fulfilling the possibilities foreseen and the work begun in earlier periods. The first book on lipreading, by John Bulwer,[1] was published in 1648, and in the previous century a Benedictine monk, Pedro Ponce de Leon, seems to have been successful in teaching deaf boys to speak. The first public school for the deaf, which became the National Institution for the Deaf at Paris, was founded by the Abbé de l'Epée (1712-89), whose methods were carried by Gallaudet to the United States.

It was in Germany, however, that a system of educating deaf children through lipreading, speech and reading was fully developed, and in Great Britain and Ireland it is thanks to such pioneers as Thomas Arnold, Van Praagh, A. J. Story and Kerr Love, amongst others, that oral education has become general. The realisation of the value of lipreading to adult sufferers from deafness, the development of methods of teaching them to lipread, the establishment of clubs for the hard-of-hearing and, later still, of clinics for giving advice about hearing-aids and lipreading, have all followed.

There is no need to give in detail here the long history of the alleviation of deafness by education. The outstanding landmarks have been mentioned to show that the principles and methods of to-day are no mushroom growth. They have been built up slowly and painfully by the life-work of men and women in many countries.

This is officially recognised, and it is significant, for instance,

[1] Early literature relating to the deaf is summarised in Thomas Arnold's *Teaching of the Deaf and Dumb*, revised by A. Farrar, 2nd edition, Derby, 1923. This and the works of the other authors mentioned here may be borrowed from the Library for Deaf Education, the University, Manchester.

that the Annual Report of the Chief Medical Officer of the English Board of Education, published in 1936, recommended that "Children whose dullness of response is thought to be due to deafness, whether mental deficiency is suspected or not, should not be sent to schools for the mentally defective until they have had a trial at a school for the deaf. There it will soon be ascertained

(*a*) whether the child is deaf or not, and
(*b*) if he is deaf, whether he is educable in a deaf school or not" (p. 123, 1935 Report).

In this book, then, the writers have tried to show that chronic deafness, whatever its form or extent, at every age and stage and in every walk of life, can now be detected, measured and alleviated more effectively than at any previous time. The fullest alleviation can only be obtained by education as well as through mechanical invention. The need of sufferers from deafness is very urgent for fuller understanding, for far more facilities for technical advice about hearing-aids, and for training in readjustment.

This need can only be met as the result of action and effort by the general public in combination with professional workers. Many a man or woman whose happiness and social life are to-day being step by step destroyed by deafness could be saved. The young adolescents leaving our schools for the deaf and partially deaf could with more sympathetic help enter more freely into a wider society.

It takes two to hold a conversation, and if one of them has imperfect hearing the other can, with knowledge of his difficulties, go far to help him out. If many more people will make sure that they have this knowledge they can bring about a new charter in our time for sufferers from deafness.

CHAPTER II.

THE DEAFENED ADULT.

In October, 1934, a clinic for the deaf was established in the Department of Education of the Deaf at Manchester University. So far as is known this was the first public clinic of its kind in the British Isles. Over a period of many years requests had been received by the writers from doctors, school medical officers, otologists and others, to give advice to patients and to the parents of deaf children, about education and lipreading, defects of speech, and, latterly, about hearing-aids. With the growth of research in the department the number of patients increased. Because of this, the clinic was established. It is hoped that in the near future more clinics will be founded in other parts of the country.[1]

The results of tests of 1037 adult patients and deaf children have been analysed, and certain conclusions about the use of hearing-aids have been reached and are summarised in this chapter in general and non-technical terms.

The figures given below state the percentage of a total number of 658 adult patients who were able to benefit from the use of a modern valve hearing-aid (see Diagram 1, p. 12).

The methods which have been evolved to make certain whether a patient receives enough help from an aid to justify its purchase will be described, step by step, in succeeding chapters. It will be seen that a majority of patients, 80 per cent., were found able to use an electrical valve aid with definite advantage. Patients unable to benefit from the use of electrical aids but who are not totally deaf, can nearly always obtain some help from a speaking tube.

Blind-deaf patients are not included in the percentage just

[1] A clinic for the deaf has now been organised at University College Hospital, London, by Dr. P. M. T. Kerridge.

quoted. They have been considered separately (see Diagram 2) and 66 per cent. were able to benefit from the use of a valve aid. Again a majority could use a valve aid successfully, but it is a smaller percentage and subject to qualifications which will need further discussion.

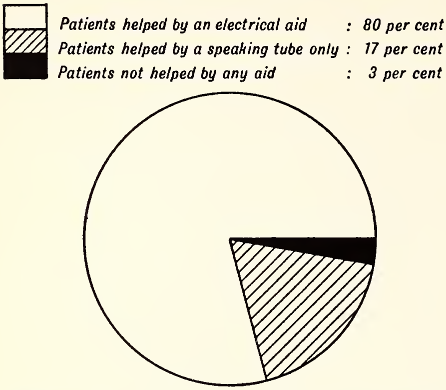


Diagram. 1.—Percentage of 658 adult deaf patients helped by an electrical hearing-aid.

The foregoing figures give the percentage of patients who *can* receive benefit from the use of a suitable hearing-aid, but there are at present no figures to show how many of them actually *do* receive the maximum amount of help daily from the purchase and effective use of the aid which is most efficient and suitable to their needs.

In the clinic advice is given as the result of careful and exact measurement of each patient's hearing, both with and without an aid. The patient is asked to describe the conditions in which he wishes to use an aid. For some patients it is more urgent than for others to have, if possible, an aid which leaves the hands free. For them a wearable aid (which invariably means a less efficient aid) may be more advisable than one which is portable. Patients are warned of the difficulties of using aids in noisy places or in a hum of general conversation. They are told, unless they suffer from severe defects of sight, that proficiency in lipreading is essential to supplement the help given even by the most efficient of aids.

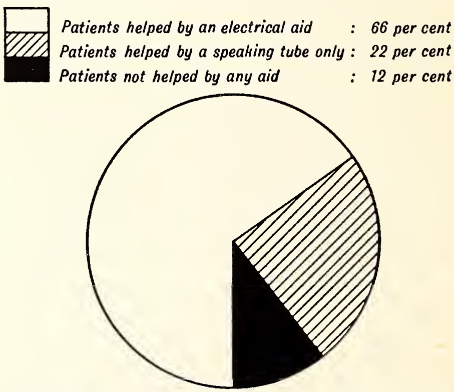


Diagram 2.—Percentage of 81 adult deaf-blind patients helped by an electrical hearing-aid.

Yet the problem of the alleviation of deafness by means of a hearing-aid can never be wholly solved within the clinic walls, no matter how efficient the tests and how thorough and well-founded the advice given. Attendance at the clinic, and subsequently at a course of lessons in lipreading, is an invaluable starting-point. There must follow a process, mainly dependent on the patient himself, of gradual adjustment to deafness, of learning how to get the maximum help from an aid and from lipreading day by day.

There are many factors which play a large part in determining the usefulness of a hearing-aid in the world outside the clinic, where circumstances are often more complex and less favourable to obtaining the best results. These factors relate to the physical nature of the deafness and to the general condition of health ; to the temperament, intelligence and experience of the patient ; to the careful upkeep of the aid ; to the acoustic properties of the places in which the aid is used ; to the presence or absence of external noises and noises which are intrinsic to the aid itself ; to the physical nature of the speech or other sound which the patient wishes to hear ; and in the case of speech to the rate of utterance and the distance from which the words are spoken into the microphone. The analysis of these factors leads to information of general and of particular interest.

Apart from the subject of the detection of deafness, this book deals exclusively with the steps which need to be taken when a patient has been warned by his medical adviser not to expect improvement as the result of treatment or surgery.

Information about the situation and history of the physical defect which has caused deafness is, however, an essential link in the steps taken towards its alleviation. The otologist's opinion is needed as to how far the nervous mechanism of the organs of hearing is involved and whether the deafness is progressive or likely to be stationary in character. If there is the slightest risk that the deafness is progressive, action must be taken to forestall social, temperamental and mental damage. Prevention is both easier and more effective than patching up after the worst has happened.

Measurements to determine what capacity to hear the patient possesses are essential at the onset of deafness, and their repetition at periodic intervals is advisable. To the

otologist they are invaluable as showing the effects of treatment. On the basis of these measurements also, the patient and those about him may learn in what conditions he can hear sound. Nothing is more destructive of the happiness of a deaf patient than the strain of constant ineffectual attempts to hear. The use and understanding of modern tests of hearing should go far to prevent the appalling intellectual and emotional waste associated with deafness in the past.

The extent to which deafness constitutes a social handicap to a particular patient depends not only on its degree and character but on his intelligence, previous education and experience.

The use of the ordinary telephone system by people with normal hearing shows these factors at work. It is a common experience that unfamiliar or unexpected words are difficult to hear in precisely the same conditions in which familiar words and phrases give no trouble at all. This is not because the component vowels and consonants are any more difficult to hear in unfamiliar than familiar words. In any one language all words, proper names included, are of course built up from a limited number of vowels and consonants which are used over and over again. Indeed, speakers usually take pains to say words or names which they think new to the listener with particular distinctness.

The explanation (familiar to many readers) is that no ordinary telephone conversation is really perfectly and completely heard. The mind of the listener is always at work filling in gaps and ignoring imperfections. The " f " in " four " if isolated might be indistinguishable from the " th " in " thought," but " thought " ends in a " t " which may be partly or wholly heard and in almost every conceivable sentence where " four " would make sense " thought " would not.

As heard by the listener " candle " may be indistinguishable from " handle," " door " from " drawer " and " bread " from " spread." Usually, however, he is not aware of this because he is not required to recognise such words singly and in isolation but only in the middle of a phrase or sentence. Context often makes the identification of words an unconscious and apparently effortless process ; but slowness of mind, deficiency of vocabulary, lack of confidence, inexperience of the habits and thought and of the speech of the person at the

other end of the telephone—all these and other similar factors may interfere with ability to make sense of what is imperfectly heard.

On a certain island off the Western Coast of Scotland there is a curious erection built in the shape of a tower. No doubt it was once a fortress but nowadays it is inhabited by a solitary man. To quote the words of his fellow islanders, " he keeps himself to himself." The tower and its inmate are regarded as curiosities. Any human being who voluntarily withdraws from association with his fellow-men to live alone is looked upon as, at least, a queer fellow.

If after an otologist has diagnosed chronic deafness he added the words " and its threat to normal behaviour," he would be saying no more than the truth, but the words would shock the patient profoundly. The cause of the threat is to be found in the social isolation, which chronic deafness, if not alleviated, so often imposes on its victim.

A fear of isolation appears to lie in the minds of many deaf patients, for there are some who deny the existence of their deafness and others who try to minimise the extent of their hearing loss. They seem to think that the acknowledgment of deafness is an admission which will cause people to avoid them. In refusing to acknowledge their handicap they are refusing to take the first step towards the very precautions which can lessen their chances of becoming ineffective in business and more or less socially incompetent.

To-day there is help of one form or another at hand for every deaf person who is prepared to exert himself to obtain it, and whose friends are willing to co-operate with him in his search. The nature of the handicap which deafness imposes is positive, as well as negative. It is not merely failure to hear this or that, but more or less, according to its severity, it interferes with and cuts off the contacts which are vital to normal behaviour and for normal communication.

As a rule, when a deaf person refuses to admit his deafness, other people, at least for a time, make an effort to help him. They raise their voices when they talk to him and they often undergo a good deal of strain to keep him informed about mere trivialities. The help they offer is proof that deafness is not hidden. It may remain unacknowledged in words, but it is useless for any deaf person to delude himself into

believing that his deafness will not be revealed. He has no way of knowing how many times he misses words, which are spoken in his presence, but of which he is unaware.

For a while, partly owing to other people's efforts, he may imagine that he can manage without help. He may not realise that people who address him raise their voices, because to him the volume of all voices appears to be cut down. He is apt to think he is hearing normal, quiet voice, when actually the voice is louder than normal.

If his deafness progresses or his environment suffers change, sooner or later he finds himself unable to cope with difficulties with which he has not been in the habit of reckoning.

It is inevitable that he should withdraw from social affairs and begin to avoid people. He may then spend too much time alone and brood about his trouble. His kind of isolation is different from that of the old man living in the Scottish castle. Withdrawal from the world was voluntary in that case but it is involuntary in our deaf man. It was his dread of loneliness that caused him to refuse to admit deafness. Temperamentally he is a sociable fellow. Lack of clear thinking has brought him to the very predicament he dreaded. If he is not prepared to exert himself and to make use of every form of help available, he is forced to live a life of withdrawal. His interests become narrowed ; repressed social tendencies may cause bitterness and suspicion to flood his mind. Through reading he can keep himself informed about local and world events, but he cannot keep in touch with human nature nor be ready to see the other man's point of view, because as a rule sympathy and flexibility of mind are the direct outcome of mixing with one's fellowmen. A minority, but still a considerable number of the patients who come to the clinic, humbug themselves about their deafness. Some of them ask for an " invisible " form of aid and refuse to use one which can be seen, in spite of its proved efficiency and suitability. Others object to lipreading because it takes time to learn it.

It is often surprising also to hear the comments made about aids by the friends who accompany patients to the clinic. " No one would know that that is a hearing-aid . . . it looks like a camera . . . or a small wireless set . . ." or, in one instance, " like a bird-cage ! "

Why should one want a hearing-aid to look like something

else? Spectacles are taken for granted and are worn when necessary as a matter of course. Hearing-aids have come to stay. No doubt in time they will change their form. Already they are becoming less cumbersome and more efficient, and the old stigma attached to their use is beginning to die out, but slowly, very slowly.

Unfortunately, among the people who are most prejudiced against them are some patients who could benefit greatly from their use. Knudsen and Jones, in an article in *The Laryngoscope*, state: "It is most unfortunate that perhaps only one out of fifty persons, who certainly should have an artificial aid, actually uses one." [1]

Happily the majority who visit our clinic face deafness and its consequences squarely. They are only too anxious to avail themselves of any form of help that can mitigate the inconvenience of deafness for themselves and others. They are willing to spend themselves and their money and to sacrifice much to obtain help.

Even so, among these patients the results obtainable with a hearing-aid vary. Both mind and temperament play their parts in the interpretation of words or partial words heard through an aid. The extraneous noises which steal through a hearing-aid disturb some patients more than others. Such sounds disconcert patients who are very sensitive to noise, whereas they pass almost unnoticed by those who can concentrate their whole attention on the words. The state of health of the patient also affects the results obtainable with a hearing-aid. Nervousness and fatigue increase the effort required for attentive listening, which in its turn can induce mental fatigue. The mind may then become less quick in following the words or parts of words heard.

This explanation probably accounts for the opinion, which has been expressed from time to time, that the use of an electrical aid can increase deafness. Results of investigation into this problem give definite evidence to the contrary.

Nevertheless a patient who uses an aid needs to reckon with the possibility of fatigue and its effect upon hearing. Any fatigue caused is due to the strain of continued attentive listening, and is not caused by the amplifier, which obviously

[1] Knudsen, V. C., and Jones, J. H., 1935, "Artificial Aids to Hearing," *Laryngoscope*, 45, 1, p. 48.

acts in the opposite direction, and reduces the amount of strain and fatigue in proportion to its efficiency and to its suitability for the particular patient.

In addition to the price of an electrical hearing-aid there is also " running " cost. This includes the recharging of wet or the replacement of dry batteries, at periods which vary from about 12 to 18 hours' use. A certain amount of deterioration occurs in wet batteries even when not in use, but in dry batteries such deterioration does not occur, to any serious extent. There is also the cost of replacement of the high-tension battery from time to time.

It has been calculated that it costs approximately 1d. per hour to run a two-valve amplifier and approximately 2d. per hour to run a more powerful and accurate model of the transverse current type.[1] These calculations are based on the requirements of patients for whom the aids are efficient at less than their maximum strength. A watchful eye should be kept upon three important parts of an aid : batteries, microphone and earpiece or telephone with its attachments. Most efficient results are obtained when the low-tension battery is fully charged. As it runs down the efficiency of the aid deteriorates, particularly for speech which is spoken at a distance from the microphone.

A very severely deaf patient may therefore only be able to hear with an aid when its output is at maximum strength and accuracy. If its output falls below that level, speech becomes for that patient proportionately more difficult to follow, and he would be obliged to renew the batteries more often than would be necessary for a less severely deaf patient. Running cost would therefore be proportionately higher.

A simple test should be made daily to prove whether or not an aid is in good working order. If the telephone be brought near to the microphone " howling " should result. Most patients can soon learn to estimate the capacity of the battery from the resulting " howl " when the telephone is held 4 inches, 1 foot or 2 to 3 feet from the microphone.

All carbon microphones tend to give less good results when the carbon granules or powder inside settle down and become

[1] Dr. T. S. Littler, Special Lecturer in Acoustics in the Department of Education of the Deaf, University of Manchester, has kindly supplied these figures.

clogged. It is advisable therefore to shake or tap the microphone from time to time. Patients should always consult the makers of an aid about this point. Aids fitted with crystal microphones do not need the same attention.

These parts should all be examined frequently to make sure that there is no detachment or weakness which would interfere with the efficiency of the aid's output.

It is not always understood by patients that when aids are tried in a clinic, consulting room or commercial apartment, the best possible results are obtainable, because of the favourable conditions. As a rule the room itself is especially equipped to prevent reverberation. In our clinic the ceiling of the room in which the tests with aids are made is covered with special sound absorbent material. The results of tests are therefore obtained under very good conditions for hearing. This fact is always explained to our patients, who must be prepared for less good results with the same aid, whenever conditions for hearing are less satisfactory.

The reverberation which takes place in many buildings interferes with the intelligibility of speech, and is apt also to give an effect of harshness to the voice tones, which often appear to be prolonged or, as it were, to overlap, thus adding a sense of confusion to the listener. Patients are urged very strongly never to buy an electrical hearing-aid without first being given the opportunity to try it at home and in other places where it will be used.

Laughter, fidgeting, the rattling of paper, all such noises can blot or mask words or even whole sentences for the patient who is listening to speech through an electrical aid. The writer recalls a recent experience in a village church. She was listening through a portable hearing-aid at some distance from the pulpit to a sermon. Close to her there was a member of the congregation who had a hacking cough. The volume of the sound of the cough was greater than that of the voice of the preacher, moreover the cough was uttered much nearer to the microphone. Again and again it masked not only the sound of words, but of whole sentences, the meaning of which would have been lost entirely but for lipreading.

A patient who uses a hearing-aid must be prepared to put up with the unpleasantness and interference to hearing of the many noises which are made habitually, wherever people

gather together. Normal listeners may be disturbed but to a lesser extent by the same noises which lie, as it were, in the background of their sound picture. For the deaf person, however, listening through a hearing-aid, amplified noises seem to creep into the foreground of his sound picture, and to throw it completely out of perspective.

Broadcasting has brought home to most people the importance of the speed factor in speech. Very fast speech makes a greater demand upon a listener's attention than speech which is uttered less quickly. The reproduction of fast speech through a microphone appears to be less accurate even to a normal listener. A deaf listener therefore is at a great disadvantage when people talk to him very quickly through a hearing-aid.

With all aids there is a limit to the distance from the microphone at which speech can be spoken, without seriously interfering with the accuracy of its reproduction. For the deaf person there is the additional limit which the degree of his deafness imposes. Lipreading can help to minimise the serious disadvantages which attend the use of a hearing-aid in public places. This was clearly shown in a series of experiments which were carried out to compare results obtained by

A, lipreading alone ;

B, hearing alone (through the particular aid which gave the maximum amount of help to the patient being tested) ;

C, combined lipreading and hearing (through the selected aid).

Lists of nonsense syllables were chosen as the material of the tests, the object of which was to estimate the actual gain in the number of vowels and consonants perceived, apart from the help which is invariably derived from context in both lipreading and hearing. Diagram 3 illustrates the results which were obtained.

The shaded area represents the average proportion of consonants scored in each test. Two speakers took part in the tests. In A no sound of voice could be heard. In tests B and C the speaker's voice was maintained at a constant level of loudness by means of an output meter connected to an independent amplifier.

The significance of the ability to lipread is also borne out by the results of the tests of hearing made in the clinic with blind-deaf patients. These tests show that speech must be spoken nearer to the microphone than is necessary for sighted patients, suffering from the same kind and approximately the same degree of deafness.

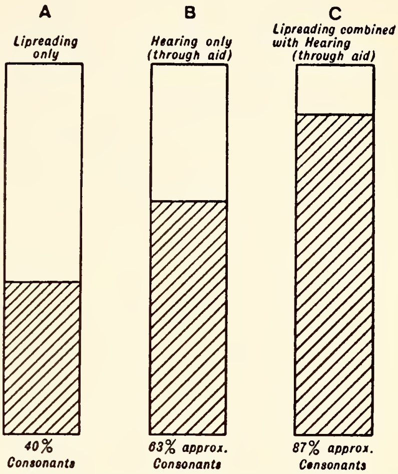


Diagram 3. — A test of lipreading ability with and without a valve hearing-aid.

The close study of the facts dealt with in Chapter X will help patients to understand some of the apparent inconsistencies in the results obtained with hearing-aids. It will be remembered that approximately 20 per cent. of the patients tested could not be enabled to hear with any form of electrical aid, yet in the tests made with an audiometer very few of them were shown to possess no useful hearing for speech. Patients who cannot be enabled to hear with an electrical aid can be divided into four groups :

(*a*) those who in old age become hard-of-hearing ;
(*b*) those who have suffered from chronic partial deafness earlier in life and who also suffer from old age deafness ;
(*c*) those who suffer from severe inner ear and nerve deafness : in this group is included a number of blind men and women ;
(*d*) those who are so severely deaf that they cannot hear the human voice in any circumstances.

Tests made in our clinic of the hearing of patients suffering from old age deafness, but not from severe deafness, show without exception that the hearing loss is only severe for the higher notes within the speech range and that hearing for the lower notes is relatively normal.

Sufferers from this form of deafness do not, as a rule, find

electrical hearing-aids satisfactory. Normal speech can be heard comfortably with the unaided ear in favourable circumstances. Amplified speech appears to these patients distorted and unintelligible. One old lady described it as "a medley of sounds," another said, "those are not words—they are clucking sounds."

The simplest and most effective form of help for this type of patient is given without a mechanical aid, when words are spoken at normal loudness, but never quickly, within his range of hearing in a quiet room. The writer always imagines an invisible circle drawn round the elderly hard-of-hearing patient. All normal speech within that circle, whose radius may be anything from 1 to about 4 or 5 feet can be heard comfortably by the patient, but speech which is spoken outside the imaginary circle becomes inaudible to him, in proportion to its distance from him. A babble of voices, or the hum of general conversation, makes hearing especially difficult for this type of patient, because so many of the essential parts of words and sentences are masked by the hubbub of noise. Listening in such circumstances makes a very exhausting demand upon mentality.

The effect of very loud speech uttered close to the ear of the old age hard-of-hearing patient is very unpleasant and usually fails in its purpose, because the ears become overstimulated and overloaded. In old age the eyes seem to shrink from very bright lights and the ears from very loud sounds.

Our records show that in a small proportion of instances a whispering tube or auricle can give a measure of help to patients who suffer from severe inner ear or nerve deafness when an electrical aid has proved to be useless.

Slow, clearly articulated speech, at normal conversational loudness, gives the best results down a speaking tube. The hard-of-hearing and the severely deaf patients who cannot benefit from the use of a hearing-aid need the utmost help and consideration that can be given to them. Peaceful surroundings, sympathetic understanding, unhurried communications can do much to help a patient to make the most of what he hears and sees, or hears only, of speech. Loud voices, hurried speech, impatient, restless talkers, an atmosphere of pressure and rush, are some of the cruellest factors with which an elderly deaf patient has to contend to-day.

For a totally deaf patient there are only three possible forms of help—lipreading, writing and finger-spelling. The latter is but an impermanent form of writing. Lipreading is discussed fully elsewhere in this book. Finger-spelling breaks down as a satisfactory means of communication because so few people can talk on the fingers. Both finger-spelling and writing take a deaf person's attention from a speaker's face and rivet attention upon the hands. The help to meaning which changes in facial expression normally give to speech is therefore lost. Something vital to the personal quality in speech passes from it when the eyes of speaker and listener do not meet and strengthen the message the words are meant to convey.

Finger-spelling and writing can supplement lipreading very usefully, when it fails, as is sometimes inevitable. A man or woman who has become totally deaf, after having heard and spoken normally for many years, should on no account allow his own speech to fall into disuse. If he begins to rely upon finger-spelling there is considerable risk of this happening. There is a closer bond between lipreading and speech than between either finger-spelling or writing and speech. A patient who habitually depends upon finger-spelling rarely, if ever, becomes a good lipreader.

It is not possible for a totally deaf person to play a normal part in social life by any means, but by keeping vivid his memories of voice and pronunciation he can retain intelligible speech, and by lipreading he can be enabled to share in the social life of his environment to the fullest extent possible, always provided that his family and friends do their part, and meet him at least half-way.

The following points are reviewed and summarised for the benefit of deaf readers :

(1) No hearing-aid reproduces speech perfectly. Some sounds always fail to come through.

(2) As no deaf person can hear all sounds perfectly, there is therefore a further loss of sound.

(3) A deaf listener must build up the meaning of what is said from incompletely heard words and sentences (cf. normal persons listening on telephone).

(4) Listening always demands greater effort from a deaf than from a normal listener.

(5) The amount of strain upon a deaf listener depends directly upon the following factors :

(*a*) His temperament and physique.

(*b*) His mental capacity—ability to put two and two together quickly.

(*c*) The degree and quality of his deafness.

(*d*) The efficiency of his aid in varying circumstances.

(*e*) The help given by a speaker.

(*f*) The extent to which he combines hearing and seeing (i.e. lipreading) speech.

In this general survey of adult patients who have attended our clinic, it has been shown that the majority could derive very substantial help from the use of an electrical aid. In later chapters their capacity to hear, the types of aid which give them most help, and the extent to which they derive benefit, in the various conditions which occur in daily life, will be dealt with in detail. No aid, however, is perfect. Conditions for hearing are never perfect. The maximum amount of alleviation from deafness is only attained by the patient who can combine the use of an aid with lipreading.

In Great Britain to-day much is being done for the religious, social and economic welfare of severely and totally deaf adults by the National Institute for the Deaf, and by Missions, Institutes and Clubs for the deaf up and down the country. Readers who are interested in this aspect of our subject are referred to the following publications :

"A Study of the Deaf in England and Wales, 1930 to 1932," by Dr. A. Eicholz, C.B.E. H.M. Stationery Office ; and "All About the Deaf," published by the National Institute for the Deaf, Gower St., London, W.C. 1.

CHAPTER III.

LIPREADING.

SPEECH-READING, more commonly and less correctly called lipreading, may be defined as the ability to understand speech by watching the movements made in speaking. English words are composed of vowels and consonants which are sometimes spoken of as "sounds."

The normal ear is equipped with a mechanism which can hear and differentiate between these sounds, and which can appreciate the fine modifications which occur when they are combined in words. In speech-reading the eyes concentrate upon the movements made as words are uttered. Every movement is not visible—many of the sounds cannot be identified visually. For example, the final "n" in the word "man" can be heard clearly, but it cannot be seen.

There are some consonants which are rarely, if ever, confused by the normal ear, but which appear to the eye as identical movements. Compare the words "view" and "few" or "seal" and "zeal." When heard, "v" is not easily mistaken for "f" nor is "s" for "z." But the movements for "v" and "f" appear alike, as do also those for "s" and "z." Such possibilities of error frequently occur. There is always, therefore, a physical limitation to results which can be achieved through speech-reading alone. The lipreader most often becomes aware of this limitation when striving to lipread unfamiliar names of persons and places, technical terms, or an unknown foreign language, or when the context is difficult.

By hearing, almost every sound in conversational speech can be identified, but there is not usually any effort at conscious analysis. Meaning is built up from words heard as a whole. For speech to be understood, it is not necessary that every sound in every word should be audible. Such a condition is rare in modern life. Hurried speech, external noises, bad

acoustic arrangements are all contributing factors to the inaudibility of speech sounds.

Listening, that is attentive listening, becomes more and more necessary as conditions for hearing become worse. Most people have had the experience of listening to conversation on a bad telephone line. Interpretation of the indistinct words and sentences heard is not brought about by analysing the sound of the vowels and consonants, but by a process of putting together all the clues to meaning. The mind and brain as a whole, and not merely the ear, function. An alert mind can gather the meaning more quickly and accurately over a bad telephone line than that of a slower thinker. This explanation applies also to lipreading. The limitation which the invisibility of some sounds imposes is not final. There is always a measure of compensation contributed by the mind, in proportion to the speed at which it can gather meaning from imperfect or indistinct word patterns.

Some factors make speech-reading extremely difficult. Chief among them is the tendency, so common in many English persons, to speak with an impassive face behind closed lips. The position of a speaker and the bodily movements he makes, may interfere seriously with the comfortable seeing of speech. Lighting in a room is more important to a speech-reader than its acoustic properties are to a listener with normal hearing. A dazzling light or shadows on the face of a speaker greatly handicap a lipreader.

The value of speech-reading for an adult can only be understood and rightly estimated when considered in relation to the degree of deafness. The ideal help to be sought for every person with impaired hearing is some means by which he can be enabled to make most use of whatever hearing capacity he has retained. Only in cases of total deafness to speech can hearing be ignored. Speech-reading is often thought of as a substitute for hearing. With certain limitations that is true in the case of the totally deaf, but it is lamentable to think of it as such for patients who are only partially deaf.

Speech-reading should aid the interpretation of partly heard words. It can give meaning to otherwise meaningless sounds at every stage of deafness, from the so-called hard-of-hearing stage to that of great severity, when only the sound of voice, but not distinct words, can be heard through a powerful amplifier.

It is frequently suggested that a patient who learns to lipread will not use his hearing to its fullest extent. This criticism of lipreading is usually made by persons who have not experienced deafness. A drowning man is said to clutch at a straw ; he would not be likely to ignore a life-belt if one were at hand. Capacity to hear, no matter how little, is a life-belt in the sea of words that washes over the head of a deaf person. There is no danger that he will ignore the life-belt. His capacity to hear will not atrophy unless he becomes apathetic, and, on that account, begins to ignore the little he hears. Speech-reading is a positive antidote to apathy. It offers a source of mental stimulation. For that reason alone it is of value to the deaf person, who of necessity must lose many other opportunities of mental stimulation.

The results of the tests of patients who have come to the clinic, show that those who retain any useful hearing recognise fewer consonants than vowels. As has already been pointed out, every consonant is not lipreadable, but even so there can be an awareness of it in the mind of the speech-reader, for context almost invariably can act as a guide.

A successful speech-reader who learns to combine hearing and lipreading experiences three effects. His hearing will appear to improve. He will suffer less mental fatigue, because by combining hearing and lipreading he lessens the strain upon his mind. He will benefit from the mental stimulation which speech-reading affords, and therefore will be in a state of greater mental readiness to gather meaning from words, when they are imperfectly heard and seen.

The ear is the natural path along which words normally travel to the brain. The eye at best is a " substitute " way, an artificial path, which must be used to meet the needs of the unnatural condition of deafness. A partially deaf person should keep the natural way in view, and think of hearing rather than of speech-reading. He will do this if, whenever possible, he is enabled to hear the voice of a speaker, even though he may not be able to distinguish any words. The sound of voice excites an instinctive response which can be aroused in no other way, a response as deep-seated in its origin as the call and answering call of bird to bird.

The position of the partially deaf listener who lipreads can be compared to that of a man who has one natural and one

wooden leg. He thinks of walking as a natural act, achieved by the help of an unnatural aid. Hearing, even though only partial, should be thought of as the natural way, and lipreading as an artificial but very useful aid. Actively combined they bring about the maximum amount of alleviation possible in the circumstances.

From reports of many patients who have attended our clinic or classes for lipreading, it is clear that there are two points of view expressed by otologists, about the degree of deafness at which lipreading should be encouraged. One opinion holds that it is better to postpone the study of speech-reading until deafness is severe. The other view claims that the study should begin at the onset of chronic deafness.

From a long experience of teaching speech-reading to pupils suffering from every degree and kind of deafness, and from personal experience of deafness and of lipreading, the writer supports the second point of view. It is incomparably harder to acquire speech-reading when deafness has become so severe that no sound of speech or voice can be heard, and at every stage of deafness lipreading offers compensation for hearing loss.

When deafness is progressive, and the patient has begun to make use of lipreading early in the course of the disease, adaptation takes place as deafness increases. Hearing and lipreading are combined, in proportion to the patient's immediate needs, and he is therefore less aware of the advance which the disease makes.

Every otologist gives warning that strain and fatigue increase deafness. Speech-reading reduces, though it cannot abolish, all the strain of listening. On that ground alone an early start is not only justified, but urgent.

As has already been pointed out, the aim of speech-reading for the patient who retains some capacity to hear is to enable him to make the maximum use of that capacity. With this end in view, he should analyse what he can hear in ordinary conversation, so that he may know just which vowels and consonants he misses. He should concentrate on them first. This is important also because it can help to prevent defects from creeping into his speech.

Practice in speech-reading should be taken at different distances, so that sometimes the lipreader may hear more and

lipread less, and at other times hear less and lipread more. The aim is to lead him to combine hearing and seeing at all possible distances when he uses the unaided ear or a hearing-aid.

The same underlying principles apply to children suffering from defective hearing which does not amount to severe deafness. This group includes :

(i) children who can be described as being hard-of-hearing, having a hearing loss of approximately not more than 20 to 30 decibels ; [1]

(ii) children whose deafness is slightly greater than this.[1]

The former can hear ordinary conversational speech comfortably, but they need to listen attentively to hear speech at a distance. If a hard-of-hearing child be always given a front place in the class, and if he be encouraged to form a habit of watching while he listens to speech, no definite lessons in speech-reading should be required. The important point here is that measurements of his hearing should be made from time to time, to ascertain whether or not his deafness is progressive, so that if necessary remedial steps may be taken to prevent further loss.

The second group contains children with varying degrees of deafness not amounting to severe deafness. They are commonly described as being partially deaf. It is advisable that all children in this group should learn to lipread, but they should be encouraged to regard speech-reading as an indispensable aid to hearing, and not as a subject or as an end in itself.

The value of speech-reading for this group can be compared, in one way, to that of the study of phonetics when learning to speak a foreign language under normal conditions. Both speech-reading and phonetics are but means to a more important object.

This attitude to lipreading is vital in the case of children. It encourages the application of the habit in all the circumstances of the child's life. On psychological and social grounds it is also very important. It is one of the ways to defeat the over-sensitiveness which so often comes to the partially deaf adolescent boy or girl.

[1] Chapter XI.

A youth with severely defective vision wears spectacles quite naturally and simply. He does not think of his defect in terms of blindness. He takes stock of his limitation and adapts himself to it.

The partially deaf child from early childhood should be encouraged to think of himself as a person who can hear, not as a person who is deaf. He should be led to realise the limitation of his hearing and the compensation which speech-reading and a hearing-aid can give him. At adolescence there would not then be heard the artificial protest that at present is sometimes made in our clinic, " I do not like to be seen using a hearing-aid," or " I don't like to look at people when they're talking."

There are two types of patients who suffer from total deafness which has been acquired after a period of normal hearing :

A. Patients who after having heard and spoken normally over a period of years gradually lose all hearing for speech.

B. Patients who after an accident, or severe illness, such as meningitis, spotted fever, influenza, *suddenly* lose all hearing.

In either of these cases the position with regard to speech-reading is similar both for the child (above the age of 9 or 10 years) and for the adult.

If patients in Group A have practised lipreading from the onset of deafness, they will accommodate themselves, step by step, to the harder condition imposed by total deafness.

The process of " adaptation " spoken of earlier in this chapter will take place. When the time comes that the sound of voice is missed, and the vital spark, which lights speech, is lost, the habit of lipreading, already established, will prevent mental shock and the feelings of complete isolation and desolation, which so often accompany total deafness.

The following descriptions are typical of many patients in Group B :

F. K. A girl, heard and spoke normally until 9 years old. Developed mumps. During this illness woke one morning totally deaf. Hearing has never been recovered.

N. S. A man with normal hearing until age of 32. Had sharp attack of influenza—became totally deaf in three weeks. No response when tested with audiometer one year later.

Both these patients suffered severe mental shock. F. K. was a very intelligent child—could read and write to a standard rather above the average for her age. N. S. had left school at 14. He could read and write but not more readily than is customary for an artisan. Communication by writing was therefore slow and laborious to both.

Finger-spelling was obviously not suitable or advisable for these patients. It would have limited and confined communication to the few people they met who could finger-spell. Its use would also have tended to diminish their chances of retaining normal speech. Speech-reading offers to such patients as these a cheering means of help and relief.

In the total absence of sound, the meaning of words must be built up from a series of incomplete movement symbols. The number of symbols perceived will depend largely upon individual capacity, but no human eye can ever detect them all.

The new habits involved in speech-reading cannot be built on a natural basis, but they can be developed by association with habits already formed.

Normally the unit of thought expressed in words is a sentence. This fact is ignored in a method of teaching which aims at developing lipreading in the first place, by an analysis of the movements made in speech, and later by combining the movements to make words.

The writers suggest, that for these patients (i.e. those with acquired total deafness) an easier approach to lipreading is made by beginning with conversation and by encouraging the pupil himself to talk, so that the teacher's replies and his part in the conversation constitute the first form of lipreading to be offered. For when the subject of conversation is known, part of the difficulty in following is removed. Choice of vocabulary is narrowed and the lipreader's mind goes half-way to meet the words.

For patients described in Groups A and B the conversational method of developing speech-reading is also valuable because it encourages the deaf child, man or woman, to

continue to take his or her part in family and social life. As has been said earlier sudden total deafness is almost invariably accompanied by shock and despair. The patient does not know how to adapt himself to the new conditions imposed upon him by his deafness. All too often he withdraws from social life ; he becomes silent ; his thoughts naturally turn inwards and he is apt to dwell upon his handicap.

The study of lipreading, based on a conversational method, can act as an incentive to intercourse. It encourages the lipreader to share in general conversation ; it holds an immediate object before his eyes.

At a later stage a close analytical study may be made of the vowels and consonants and the part they play in words. This knowledge is indirectly helpful to many pupils, but they should not consciously try to analyse sounds and movements when lipreading.

The writers know many efficient lipreaders, particularly among children, who have acquired the art, without any form of analytical practice, though rarely without definite teaching. On the other hand, they know other persons who have been helped considerably by the analysis of speech movements.

Totally deaf lipreaders get no help towards the understanding of words from intonation and modulation of voice, in the way that is possible for partially deaf listeners, but facial expression and animation aid meaning.

The quality of a voice can be assessed by a skilled lipreader, but the stirring emotion roused by the sound of a voice or of many voices, by changes of intonation and sentence melody, can never be experienced through speech-reading alone.

Accent and emphasis can be appreciated by the eye of the trained lipreader who notices the timing of words. Stress laid on a syllable or a word usually prolongs its utterance by a fraction of time. Thus a lipreader with memories of normal pronunciation, that is the pronunciation common to his environment, may still be made aware of accent and emphasis.

Rhythm in speech can aid lipreading. Recently the writer attended a lecture. No hearing-aid was available and therefore no sound of the lecturer's speech could be heard, but his smooth, unhurried rhythmic utterance made speech a pleasure to the eye, as no doubt it did to the ears of others in the audience.

In Chapters XII and XIII of this book principles and

methods of teaching children totally deaf from birth are discussed. Speech-reading for this group of children offers allied and new problems.

The child or adult who has become deaf after having heard and spoken normally has already formed all the links in the chain which connects spoken words with their meaning. For him the process of learning to lipread is the forging of a new link in place of a damaged link in the chain.

For the congenital deaf child lipreading means much more than that. It necessitates the forging of a whole series of new links ; an entirely new chain in fact. There are no ready-made word connections in his brain, because such connections are made normally through the ability to hear.

The early years of normal childhood result in the acquisition, understanding and use of speech. At no other period in life is linguistic development so rapid as during the first five years of childhood. At every step in the "march of events" [1] which advances the understanding and use of speech, a child is in a state of mental preparedness, during these years, which makes the forming of associations between words and meaning easier than it ever can be again.

This is equally true for the deaf child, though sight and not hearing is the main "way in" by which words can reach his brain. Association of the visible word with meaning is easier to establish during the first five years of a deaf child's life than ever again.

It is therefore important that the foundation for the structure of speech be laid through speech-reading in the nursery or nursery school.

There is an urge towards expression and communication in a young deaf child, which to some extent finds outlet and satisfaction in gesture. A deaf child will point to the apple he wants. There is in his mind a clear conception of his desire. The apple is *the* thing which interests him at that moment. That is therefore the psychological time for parent, nurse or teacher to offer the spoken word "apple."

The deaf child's gesture language is a guide to his thoughts and interests. It indicates the words he is needing and for which his mind is most prepared at that moment. If the

[1] Head, Sir Henry, 1926, *Aphasia and Kindred Disorders of Speech*, i, p. 494. Cambridge University Press.

appropriate word or words are offered, then associative activity or actual association of visible word and meaning follows. This establishment of association is the first step towards speech-reading.

The nursery class offers for the majority of deaf children natural opportunities for developing lipreading on the lines suggested.

Thus, gradually, the habit of watching words can be built up. It will be strengthened by the necessary routine commands addressed to the children as a class. In the first place, the meaning of the words used in routine commands is made obvious by the situation and by the expression and helpful indicative glance of the speaker. There are four aspects of this form of mental activity to be borne in mind :

(1) perception of the visible movements ;
(2) association in the first place of the visible word and its meaning ;
(3) recall and recognition of the word when the act of association has once occurred ;
(4) growing understanding of more complex thought, expressed in more complex groups of words.

Perception of speech movements results from watching the face—not the hands of a speaker. This is one reason why the writers deprecate the use of gesture or of attempting to combine lipreading and finger-spelling. Eyes can speak, and an indicative glance can help the meaning of words uttered by the lips, without taking attention from the face.

A deaf baby who is encouraged to watch the face of a speaker begins in time to see words on the lips, particularly if association of word and meaning is made very clear.

All young children love repetition and to hear the same words and rhymes over and over again. The deaf child loves to see the repetition of words he knows, it can give him a sense of satisfaction which prepares the way for new words.

Lipreading for a congenitally deaf child can be compared to the learning of a foreign language. New vocabulary is acquired through understanding of the context, but the full meaning of the context can only be understood when the reader is familiar with every word used. Vocabulary and context react upon each other.

That is what happens when a born deaf child lipreads.

At first he gets only an incomplete impression of a new word and its meaning. The new word is only visible for a fraction of time.

In that respect lipreading is unlike reading. A reader may look at a word for as long as he likes and he can always see the whole of it. On account of the fleeting passage of spoken words and their incompleteness when lipread, the writers urge that reading should back up, at every stage, the teaching of lipreading to deaf children. The permanence and completeness of printed words stresses their entity.

It is essential that, eventually, each word image should be clear in the deaf child's mind. Blurred word imagery cannot aid clear thinking or intelligible speech ; for example, a young deaf child quickly learns to associate the movements made in saying, " open the door " with the action of opening the door, but the lipread form of the words may stand for the word " door " or for the word " open." In the first place the phrase appears to the child as one word. It is only at a later stage, when he sees the words printed, that he realises that the movements which he sees make three words.

Thus lipreading is the source through which in the first place a totally deaf child gains understanding of the purpose of speech and impressions of particular words.

Bit by bit vocabulary is added. It is greatly strengthened when he learns to read.

As his vocabulary extends, and as he begins to use words in his thinking and in his understanding of the thoughts of other people, it becomes habitual to him to lipread the people whom he knows and who use words which he has already met.

Equal success in lipreading strangers cannot be expected until later, for two reasons. There are many ways of speaking and as many individual mannerisms in speech as there are speakers. No two people make identical movements, or employ exactly the same expression when uttering the same words. Even a person with a long previous experience in hearing and understanding the speech of others finds that, only in the course of time, can he overcome the difficulties to be met in lipreading unfamiliar types of speech.

There is another reason also which makes it especially hard for a child to follow the speech of a stranger. The latter

may address him in words which he has never met before, or he may use such a preponderance of unfamiliar words that the child can only recognise an odd word here and there, but not enough to help him to make sense from them.

The position of the child is then rather like that of an Englishman in a foreign country, of whose language he has only a very limited knowledge. He would probably be able to understand sentences expressed in the foreign language spoken by another Englishman who was also not very familiar with the language. He would find it much more difficult to follow the speech of the natives, partly because he would not be familiar with their particular characteristics of voice, intonation, accent and rate of utterance, and partly because they would use idiomatic phrases and many words unknown to him. When lipreading a stranger, a deaf child is faced with similar difficulties, but he has the additional handicap imposed by his inability to see the whole of every word uttered, whereas our Englishman with normal hearing can at least hear *whole* words and sentences.

Deafness which is a result of a falling off in acuity due to old age can frequently be minimised by the help which lipreading can give. To patients suffering from this form of deafness speech appears indistinct because so few consonants, most of which are composed of the higher groups of notes, can be heard. If the eyes are trained to watch the movements for the consonants, the effect upon speech is somewhat similar to that which follows when the ear is cupped by the hand, or when a partially deaf person follows with his eyes a printed passage which is being read aloud.

Speech which is easy to hear can as a rule be lipread. When it is inaudible, because the voice is badly produced and vowels and consonants are indistinct, it is also far from easy to lipread.

Speech offered to the totally and congenitally deaf should be slower and more distinct than that which is used with patients who have some remaining capacity to hear. In no circumstances should "mouthed" words be offered. Exaggerated movements always increase the difficulties in lipreading. Whispered words are much more difficult to follow than voiced words, for there is always an unnatural quality about them.

The ideal for lipreading is normal and natural speech which is neither too fast nor too slow, spoken at a distance of about 3 or 4 feet—vowels clearly shaped, consonants articulated carefully, with no exaggerated mouth-opening or movements.

The following information may be useful to adult patients who have lost their hearing in part or completely. It is possible to learn lipreading in two ways, either by taking a course of private individual lessons or by attending a class. In many towns evening classes for lipreading are held weekly. The fee charged is small. The lessons are planned to suit the ability of the majority of the members of the class. Many students make excellent progress in this way.

Private tuition is more expensive, but as each lesson meets the requirements of the individual, progress is relatively quicker.

In either case it depends also upon the extent to which a student practises, and applies at home all that he learns during the lessons.

A course of twenty graded lessons [1] covers all the necessary theoretical knowledge, and as a rule includes also enough practice to enable the student to follow the speech of the teacher. But the aim of the course is to enable a student to lipread the speech of his relatives, friends, and of all whom he may encounter. This aim can be achieved only in proportion to the amount he practises with other people.

Success in lipreading the teacher is proof that the student is capable of becoming an efficient lipreader if the two following conditions are fulfilled. He must practise diligently with different speakers, who should meet the needs of the lipreader by speaking naturally but a little more slowly than usual and by directing their words towards him.

It is no more possible for a teacher of lipreading to ensure success to a student of lipreading who does not practise at home, than it is possible for a music master to make a brilliant pianist of a pupil who takes lessons on the pianoforte but does not practise.

The art of lipreading is progressive. There is no completion to this nor to any kind of learning through social experience.

[1] Ewing, I. R., 1930, *Lipreading*. Manchester University Press.

To converse with many different persons having different temperaments and different mannerisms in speaking, using different words and talking about different subjects, is part of man's most valuable personal experience. But it is more than that for a lipreader, because for him, conversation is the finest form of practice which can be given in the art of speech-reading. It is to be regretted that the general public in England do not, like Americans, more seriously encourage the deaf to lipread.

Only a very small minority, who happen to be born lip-readers, " pick it up " in half a dozen lessons. The majority of deaf patients need to give their minds to the subject, and to persevere with it ; then it brings its own reward in the form of life-long help in almost every social situation.

That is not to say that lipreading never fails. There are days when it enables one to forget deafness completely, but there are other times when mind and body are tired, when eyes and ears refuse to function together and the partially heard and partially seen words elude one. That unfortunate experience of " mental blur " occurs far less frequently to the lipreader than to the man who relies solely on a capacity to hear which has become defective.

To the question, which is put by almost every deaf person whom the writers meet, " Is lipreading worth while ? "—there is only one answer.

Two defective ears are undoubtedly better than one totally deaf ear and one defective ear. Lipreading offers the equivalent of an additional defective ear, and no deaf person can afford to disregard its help. Experience has proved over and over again that lipreading is infinitely worth while.

CHAPTER IV.

THE SPEECH OF THE ADULT WHO BECOMES DEAF.

It is common knowledge that a child who is totally or severely deaf from birth is dumb, because he cannot hear or imitate the words which, from infancy onwards, are spoken to him or in his presence. Dumbness has been observed as a consequence of deafness since the time of Aristotle, but it is not generally known, even to-day, that there is often a probability of deterioration in the speech of adults who suffer from acquired deafness.

The reader is asked to think of learning to talk in the first place as a process of matching patterns. A baby hears people talk around and to him. Some of the words he hears attract his attention more than others. He begins to understand their meaning and in time he begins to imitate some of them. At first his attempts are mere approximations to the words he tries to say. Gradually he learns to match more and more exactly his own word-patterns to those he hears in his environment.

Three fundamental conditions underlie this step forward in normal speech development. There must be the ability

(*a*) to hear and to perceive very fine differences between sounds ;
(*b*) to hear and to compare one's own word-patterns with those spoken by other people ;
(*c*) to call the organs of speech into action at the right psychological moment.

In this chapter it would be irrelevant to deal with conditions which relate to the motor aspect of speech development,

the automatic character of which is normally dependent upon the three considerations described above.

When a baby is learning to talk, he is not conscious of his own growing ability to discriminate between fine differences in sounds. He does not, of set purpose, match his words to the words he hears. He begins to talk without thinking about his organs of speech. As he learns to talk he goes through a series of mental and physical acts, which ultimately become habitual and result in automatic speech.

A child brought up in a Cockney home copies the Cockney word-patterns he hears, and in the same way a Lancashire child copies the intonation and pronunciation of the voice and word-patterns most common in his environment. This matching of word-patterns is a universal characteristic of normal speech development. In other words, we speak as we hear.

A Lancashire child or adolescent, who goes to live in the south, recognises very quickly that there are differences between his own pronunciation and that of southerners.

If he remain long in the new environment, his speech undergoes some changes, of which he may not be aware. He probably adopts at least a few of the characteristics of southern speech. As a rule such modifications take place slowly, because the habits formed in childhood are strong and offer resistance to the formation of new speech habits. Nevertheless they will occur inevitably in the course of time, unless the northerner makes a deliberate effort to retain his original pronunciation.

This explanation serves to illustrate the position of many patients who suffer from partial deafness. Gradually or suddenly, according to the cause and progress of the impairment to hearing, the speech-patterns which they hear become incomplete. It may be that the sound of voice is reduced, or some of the higher or of the lower groups of notes are cut off. Deafness may cause a listener to hear incomplete versions of vowels, so that they become "flattened." Many consonants also may appear to be distorted, or they may be wholly inaudible.

Tests made in the clinic give information about a patient's loss of hearing for the sounds of voice, vowels and consonants. Such tests therefore indicate the direction in which his speech is likely to fail. More than 50 per cent. of the severely deaf

patients tested in our clinic had developed defects of speech, of which, in the majority of instances, they were unaware.

Under normal conditions speech is produced automatically, but the brain requires a constant supply of complete patterns for the permanent retention of normal speech.

The crux of the matter is that a deaf person may go short of complete word-patterns. For this reason it is vitally important that only hearing-aids giving high quality reproduction should be used, both by partially deaf children and adults. An aid which distorts the sound of voice or the quality of vowels and consonants, or which fails to reproduce some of them, encourages defects in the speech of a patient who uses it habitually. He may begin to speak as he hears. On the other hand, a hearing-aid which reproduces speech faithfully is a valuable asset in the prevention or correction of defects of speech in the partially deaf.

The output of all the aids which are used in our clinic has been proved to be of high quality.

The object of the tests made is to discover, not merely an aid through which a patient can hear conversation, but *the* aid which gives the maximum number of complete word-patterns and the most natural tones of voice to the individual patient. He often appears to hear conversation equally well with several aids, but the more severe form of test on nonsense syllables which is given, invariably shows in detail the superiority of one or other aid for a particular patient. This is important, for in these circumstances the aid can help to maintain normal qualities in his speech.

As a rule the speech of an adult patient who suffers from only a slight degree of deafness remains normal. In old age habits of speech are more or less fixed. They are therefore less susceptible to change in any case, and it is improbable that defects would appear in the speech of an adult who can hear speech normally under particular conditions. The hard-of-hearing patient is different from all other deaf patients since either he hears speech or else he does not hear it because it is masked by other sounds. His deafness causes him to hear speech more faintly than the normal listener, but not so faintly as to lose essential parts of word-patterns. His speech therefore is not threatened in the same way as theirs.

A study of audiograms of patients suffering from deafness

which has been diagnosed by an otologist as chronic middle-ear deafness, shows that as a rule they retain some capacity to hear over part or all of the range of frequencies involved in speech. The loudness of speech is cut down for these patients, in proportion to their degree of deafness, and words become unintelligible in proportion to the loss of hearing for vowels and consonants. The patient's standard of loudness may change and he may begin to speak too quietly.

People who are not deaf hear their own speech in two ways :

(i) by air conduction,
(ii) by bone conduction (through the bones of the skull).

A patient whose deafness is entirely due to disease or defect in the middle ear may be able to hear very little of his own speech by air conduction, and yet able to hear it to a normal extent by bone conduction. This is an immense advantage which a severely nerve deaf patient is denied. The latter cannot hear his own speech clearly in any circumstances, neither by air nor by bone conduction.

A middle-ear deaf patient often drops his voice because his speech appears louder to himself than it does to other people. This is largely because he lives in a relatively quiet or silent world, whereas normal listeners, who continually hear external noise by air conduction, talk loudly enough to hear themselves speak above it.

The middle-ear deaf patient may be able to hear and to criticise to some extent the quality of his own voice and pronunciation. But although he can do much by his own unaided efforts to prevent deterioration in the intelligibility of his speech, he may have great difficulty in estimating the loudness of his voice. For instance, in a noisy place, such as a tram or train, or in the city when the traffic is heavy, most people raise their voices to make themselves heard above the noise. The middle-ear patient also probably hears some of the external noises, but they do not appear nearly so loud to him. When he raises his voice, the effect which he experiences, mainly through bone conduction, is that of shouting. It is an unpleasant sensation, almost like reverberation in one's own head. Nevertheless he must learn to accommodate skilfully the loudness of his voice to the requirements of listeners, in many different circumstances and places.

Defects frequently occur in the speech of adults suffering from nerve deafness, which is

(*a*) partial, (*b*) very severe, or (*c*) total.

These three groups of patients suffer loss of hearing both by air and by bone conduction. As a rule in groups (*a*) and (*b*) there is loss of acuity over the whole of the speech range, but the loss is most severe for upper tones.

Patients in group (*a*) can as a rule hear both their own and other people's voices naturally but diminished in loudness. They tend therefore to retain normal intonation, and all the other characteristics of natural voice, but to lose a normal standard of loudness and to speak too quietly.

Patients in groups (*b*) and (*c*) experience a different kind of difficulty. The former find it more and more difficult to hear their own voices as the degree of deafness increases ; the latter cannot hear their own voices in any circumstances.

It is natural in persons who have heard for many years to want and to expect to hear their own voices when they talk. These patients therefore try to make themselves hear their own speech, thus they habitually talk more loudly than conversation demands.

In nerve deafness hearing fails first on the highest notes within the speech range. This affects the perception of such consonants as s, sh, f, th, z, etc. These are therefore the first consonants to show defects in the speech of a patient suffering from partial nerve deafness. He may hear parts of the consonants ; he may know with certainty that they have been uttered, but he cannot

(i) hear them distinctly at a distance ;
(ii) hear them completely even when he knows they have been spoken.

The first consonant to suffer is " s," which is largely composed of the highest frequencies involved in speech. Associated with " s " are all the fine and delicate modifications of that consonant in such combinations as " st " and " ts " in *st*ar*ts*, " ks " in par*ks*, " ps " in ca*ps*, etc. Failure to hear complete or perfect consonants cuts down a patient's experience of normal patterns, and without knowing it he may often begin to talk as he hears. His speech will certainly become less distinct although not altogether unintelligible.

To the more severely deaf patients a larger percentage of the consonants becomes inaudible, or are heard in a mutilated form, and many vowels also are distorted. Thus defective consonants and inaccurate vowels may creep into the speech of these patients.

Two days before writing these words, the writer met an example of this kind of deterioration in the speech of a severely nerve-deaf adult. The word "sister" was pronounced "shishter." There were no clear-cut consonants. Many of them were slurred and words were run into each other. The voice was unnaturally loud and harsh. This patient said that she has difficulty in making people in shops understand what she asks for, and that every one turns round and looks at her when she begins to talk. Five years ago she heard and spoke normally.

In her case deafness has progressed quickly. No form of treatment has been able to cure or delay the disease. Serious deterioration in speech has followed rapidly. But it would not have occurred to so serious an extent, perhaps not at all, if steps had been taken to guard against the formation of a series of wrong speech habits.

The position of the totally nerve-deaf patient with regard to speech is even more difficult. He has only the memories of normal speech-patterns to help him. For a short time the old-established habits of speech may continue to function, but with the cessation of all auditory stimulation the conditions which govern the permanent automatic character of speech begin to fail.

A totally deaf person can be taught to control the loudness of his voice through his sense of touch. He can learn to associate vowels and consonants with the movements and contacts made by his lips and tongue in their formation ; he can learn to assess the intelligibility of his speech by other people's response to it ; to control and to modify his voice consciously.

The majority of patients suffering from acquired deafness can only retain intelligible speech if, from the onset of deafness, they give thought to the subject. They should always avoid talking quickly and should make a practice of speaking carefully. It is a good plan to take a course of lessons in voice and speech training. Above all, such patients need to watch closely the response and effect of their speech upon other people.

Up to date, no special tests of the speech of deaf-blind patients have been made in our clinic, but it has been observed that speech defects are both more common and relatively more serious in proportion to the degree of deafness than in the case of patients with normal sight.

There are several reasons for this difference. Nerve deafness is more frequent among deaf-blind than among other patients. There appears to be a bigger proportion of severely deaf than of partially deaf patients among the blind. They can get no help from watching speech.

The practice of watching words is a very valuable preventive of speech defects. The eye conveys visible speech movements to the brain, where they become associated with the patient's past or present auditory experience of words. In this way the eyes give valuable guidance to the speech mechanism.

A partially deaf-blind patient should be encouraged to talk slowly and deliberately, and all who speak to him should follow the same practice whenever he listens through the unaided ear, or when he uses an electrical aid or a speaking tube.

CHAPTER V.

HEARING, SPEECH AND MUSIC.

Two exact methods of measuring hearing now exist. The essential features of the first, the pure tone method, are already widely known because the use of electrical apparatus, such as pure tone audiometers, is the logical development of long-established tests of hearing by means of tuning-forks.

Because of the mental and temperamental factors in deafness, however, pure tone measurement of the patient's sensitivity to sound, though essential as a first step, is not enough. Another method of testing, which indicates his ability to recognise the sounds of speech itself, under carefully regulated conditions, has to be used.

In many respects the problems of testing the ability of people with defects of hearing to hear and understand speech resemble those encountered during scientific investigations of the efficiency of telephone systems. For this latter purpose a technique was evolved, especially in Bell Telephone Laboratories, New York, which has proved capable of very consistent and accurate results.

In our laboratory this system has been used to test the intelligibility of speech to patients with defective hearing and also to measure, in a reliable way, the extent to which they can be helped by different types of hearing-aids. The results have shown that this technique overcomes the difficulties involved in the earlier " Whisper Tests " and " Voice Tests " and obtains, at the same time, exact information about the patient's response to speech, the most important form of sound in human life, in what may be called working conditions. At the same time, however, pure tone measurements of sensitivity to sound, over the range of pitch involved in speech, have themselves acquired a new kind of value for deaf people.

Physicists can tell us, as the result of the most ingenious and patient experiment, exactly in what way the vowel sound in the word "two" differs from the vowel sound in the word "three," and how each of these is distinguishable from the sound of the consonant in "saw," or for that matter from middle C played on the piano. They can compare the loudness of quiet conversation with that of the noise of a railway train, a pneumatic riveter or of a typewriter. The results of all these measurements of common sounds can be compared in a very accurate way with the results of the measurement of the hearing of each individual patient. We can tell what he misses, owing to his deafness, when he listens with the unaided ear, and how much help he needs, the compensation being given through an aid if possible.

Physical nature of pure tones, music and speech.

The older, pure-tone method of testing hearing is still the most exact and precise for two reasons. The first is because the kind of sound used as stimulus is subject to very accurate control. As is well known, a tuning-fork, properly struck, produces a sound of one frequency or pitch only. By its vibrations a C fork sets up air-waves at the rate of 128 per second. This frequency or rate is the scientific equivalent of the pitch of the note C on the piano. It is one octave below C′ (or "middle C"), but while the tuning-fork emits a single or pure tone the same note on the piano is a much more complicated sound.

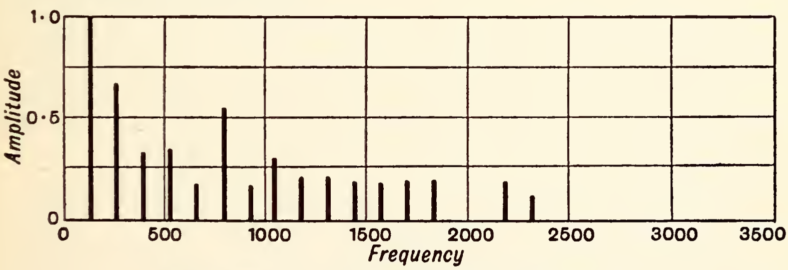


DIAGRAM 4.—Acoustic spectrum of piano C.
(From Fletcher, Harvey, 1929, *Speech and Hearing*, p. 92, Macmillan & Co. Ltd.; courtesy of D. van Nostrand Company, Inc.)

In the above diagram these two forms of sound have been subjected to harmonic analysis, i.e. split up into bits arranged according to pitch. The method used for showing the results

of this process is known as an acoustic spectrum. Here it shows that piano C is really a complex system of simultaneously produced sound. The largest component [1] in this system has a frequency of 128 vibrations per second, but there are others of varying magnitude over a wide range of pitch, some having a frequency of over 2000 vibrations per second, which is more than four octaves higher. By contrast the sound of tuning-fork C consists of one component only, of frequency 128 vibrations per second. Hence the sound of the fork is described as a pure tone.

It is useful to compare the acoustic spectrum of C on the piano with that of the same note when played on a 'cello organ pipe.

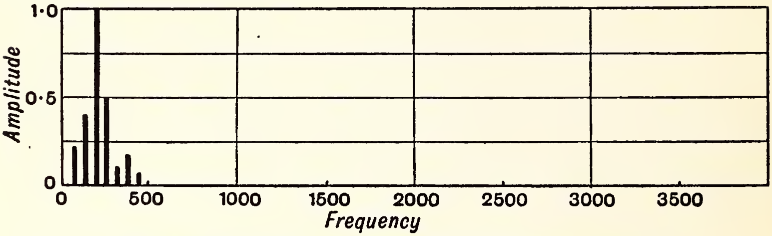


Diagram 5.—Acoustic spectrum 'cello organ pipe C.
(From *Speech and Hearing*, p. 94; courtesy of D. van Nostrand Company, Inc.)

The largest component in the sound made by the organ pipe has not the frequency of the note in the score but is an octave higher. On the other hand, there are no components at all with a frequency above 500 vibrations per second. It is mainly owing to such differences as these that each type of musical instrument has its own quality.

Vowels and consonants are also complex sounds and their components occur over a wide range of pitch. They have been analysed by Crandall,[2] Miller,[3] Paget [4] and Stumpf.[5]

[1] Dr. Fletcher kindly informs us that the scale of magnitude on which the components have been represented is arithmetical.

[2] Crandall, I. B., 1925, "The Sounds of Speech." *The Bell System Technical Journal.* Also Fletcher, Harvey, 1929, *Speech and Hearing.* Macmillan & Co. Ltd.

[3] Miller, D. C., 1916, *Science of Musical Sounds.* Lowell Lectures.

[4] Paget, Sir Richard A. S., 1930, *Human Speech.* International Library of Psychology. Kegan Paul.

[5] Stumpf, C., numerous articles in German scientific journals, 1901-21, summarised by Ogden, R. M., *Hearing*, 1924, pp. 81-102. Jonathan Cape.

It is important to notice that there is the closest consistency between the results obtained by these workers, although they used different methods.

The lowest component in the speech of a very deep-voiced man has a frequency of about 90 vibrations per second. The components in speech which have the highest pitch are found in the consonant " s " and have a frequency of approximately 8000 vibrations per second.

The range of pitch involved in speech is thus from 90 to 8000 vibrations per second, or greater than seven octaves. It begins more than one octave below piano middle C and extends to a frequency above that of the highest note on the piano keyboard.

The following are acoustic spectra of typical vowels when uttered by a male voice :

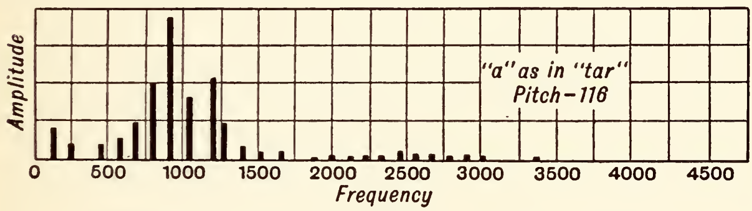


DIAGRAM 6.—Acoustic spectrum " a " as in " tar."

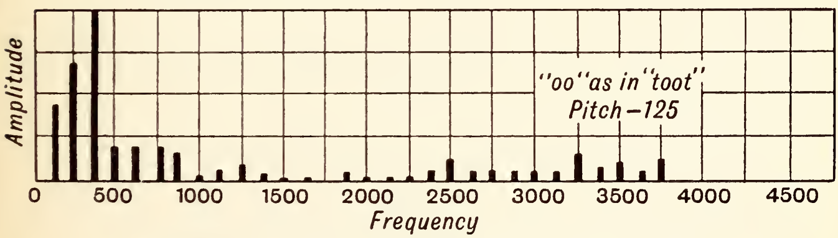


DIAGRAM 7.—Acoustic spectrum " oo " as in " toot."

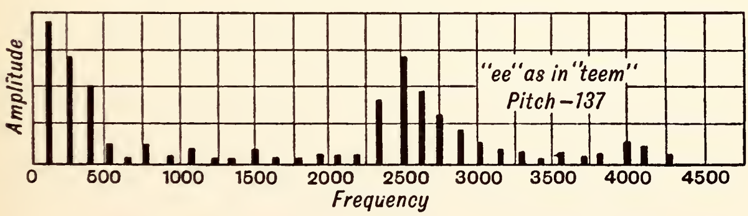


DIAGRAM 8.—Acoustic spectrum " ee " as in " teem."

(From *Speech and Hearing*, pp. 52-3 ; courtesy of D. van Nostrand Company, Inc.)

Differences in the patterns of these vowels are very clearly shown: "a" as in "tar" has its largest components about the frequency of 1000 vibrations per second. In "oo" as in "toot" they are strongest below 500 vibrations per second but occur with appreciable strength almost as far up the frequency range as 4000 vibrations per second. "ee" as in "teem" is found to cover an even wider range of pitch and to have two marked groups of components—one below 500 and another around 2500 vibrations per second.

For listeners with defective hearing the wide range of pitch over which the components of vowels (and many consonants) occur is of great practical significance.[1]

The acoustic spectrum of each vowel has always certain features which distinguish it from the acoustic spectrum of any other vowel, and these are irrespective of the pitch and quality of the voices of the male or female speakers who utter them.

The following are acoustic spectra of "ee" as in "eat" when uttered (*a*) by a male and (*b*) by a female voice:

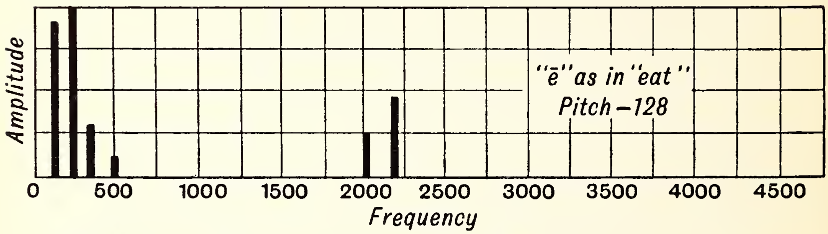


DIAGRAM 9.—Acoustic spectrum of "ee" as in "eat," male voice.

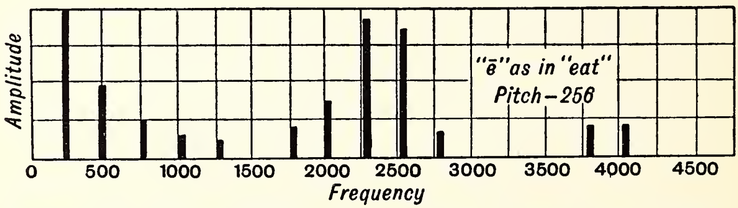


DIAGRAM 10.—Acoustic spectrum of "ee" as in "eat," female voice. (From *Speech and Hearing*, p. 54; courtesy of D. van Nostrand Company, Inc.)

The pitch of the man's voice as it would be shown on a musical score was 128 vibrations per second, or one octave below piano middle C. The pitch of the woman's voice

[1] Chapter VIII, p. 97.

similarly represented was 256 vibrations per second, or piano middle C. The listener with normal hearing readily recognises that the man's voice is lower in pitch than the woman's. Yet he also recognises that in spite of this difference both speakers are uttering the same vowel. We see from the acoustic spectra why this is so. The *difference* between the two voices is due to the fact that the man's has two large low-pitched components, one of 128 and one of 256 vibrations per second, while the woman's has one (larger) of 256 and one (smaller) of 512 vibrations per second. The *similarity* between the sound of the vowel " ēē " as uttered by these two voices, the similarity which causes the listener to know that it is indeed " ēē " and no other vowel which has been said or sung, consists of a small group of high-pitched components common to both. The pitch of these components is between 2000 and 2400 vibrations per second.[1]

This similarity in pattern is the essential feature which enables a listener to distinguish one vowel or consonant from another, in spite of inevitable minor differences between the pronunciation of different speakers. If pronunciation differences pass beyond a certain limit, e.g. in the case of the northern speaker who says " Dănce on the grăss " by contrast with the southern " Dānce on the grāss," analysis and acoustic spectra show that this is a case, not of minor differences in pronunciation but of a wholly different vowel. Listeners who are used to one pronunciation find the other odd only when first encountered, and although the vowels are different the consonants are the same. The listener recognises the words from the consonants with help also from the general circumstances and context.

The science of phonetics [2] shows how consonants are produced by co-ordinated action of the human organs of speech. In vowels and voiced consonants, e.g. "b," "l," "z," the pitch of the voice, i.e. in singing the note given in the musical score, is the pitch at which the vocal chords vibrate. Components of higher pitch are due to harmonics of this laryngeal tone and to modifications and adjustments of the mouth-opening and of the spaces inside the mouth, pharynx and nose by

[1] Fletcher, H., 1929, *Speech and Hearing*, p. 58. Macmillan & Co. Ltd.

[2] See for example Ward, Ida C., 1929, *Phonetics of English*. W. Heffer & Sons, Ltd.

movement of the jaw, lips, tongue and soft palate. Resonating cavities of different dimensions are thus formed. In the vowel "$\overline{\text{ee}}$" for instance, the high-pitched components are caused by raising the blade or forepart of the tongue until it approaches the palate. A resonating cavity of small dimension is thus formed suitable to the production of sound of high frequency.

It is interesting to compare the size and shape of the spaces formed in the mouth during pronunciation of the vowels "a" as in "tar," "oo" as in "toot" and "ee" as in "teem," and then to refer to the results of harmonic analysis of these vowels given earlier.

Complex sounds, especially those of speech, are necessarily employed in intelligibility tests. They are unsuitable, however, for making exact measurements of acuity of hearing at different frequencies. If their loudness is reduced to the level at which they can only just be heard, it is impossible to be certain (except in the use of highly skilled listeners) which of their components are giving rise to a sensation of sound. Deafness often results in patients hearing some, though not all, of the components of a complex sound, especially if their defect is greater for high notes than for low, or the reverse. This will be discussed more fully in a later chapter.

Deafness and the ear.

Another reason for the suitability of pure-tone tests as an exact means of measuring hearing lies in the mechanism of the ear itself.

Recent research by such workers as Hallpike [1] and Hartridge in the Ferens Institute, Middlesex Hospital, London, has demonstrated that sensations of sound can be produced by electrical stimulation of the ear. At present this experience is only possible in the laboratory. In ordinary life hearing is mainly the result of the mechanical impact of sound on the ear in the form of air vibrations, or, to use the technical term, by air conduction.

There is a third means of stimulating the sense of hearing, namely, by bone conduction. It rests on the fact that vibration of the bony walls of the inner ear necessarily results in

[1] Hallpike, C. S., and Hartridge, H., 1937, "On the Response of the Human Ear to Audio-frequency Electrical Stimulation," *Proceedings of the Royal Society*, Series B, No. 831, 123, pp. 177-93.

vibration of the inner ear itself. Sensations of sound can be obtained in this way when the middle ear is defective or even when the greater part of it is missing as the result of injury. To set effectively in motion a bony mass, however, necessarily means the use of a considerable amount of energy. This is only one of the many problems involved which offer great difficulty to designers of hearing-aids with bone-conduction receivers.

Judging from things said by patients there is danger that the idea may become current that some form of bone-conduction aid will help the totally deaf. It cannot be too strongly emphasised that hearing by bone conduction depends on the action and condition of the inner ear. There is no means at present known to scientific workers by which sufferers from total inner ear or nerve deafness can be made to hear. For such patients lipreading and adjustment to deafness through education are at present the only available forms of alleviation, but on these they may rely with confidence.

The cochlea is a part of the inner ear which is indispensable to the sense of hearing. It consists essentially of two minute canals or tubes containing liquid and with a flexible membrane between them. They are not straight but wound into a spiral shape like a certain type of sea-shell. If they could be unwound the cochlea would be represented by the following diagram :

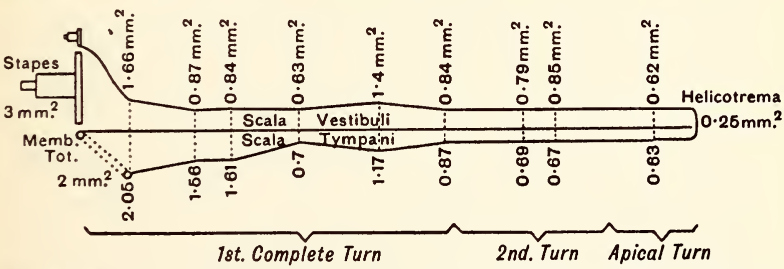


DIAGRAM 11.—The cochlea and wound nerve-endings are situated along the flexible membrane (the basilar membrane) throughout its length. (*Speech and Hearing*, p. 117; courtesy of D. van Nostrand Company, Inc.)

By means of the cochlea men and mammals [1] differentiate between sounds according to their pitch. Our understanding of its behaviour is largely due to the great nineteenth-century

[1] Beatty, R. T., 1932, *Hearing in Man and Animals*, p. 142. G. Bell & Sons Ltd.

physiologist and physicist, Helmholtz.[1] He first discovered the way in which the complex sounds of articulate speech are built up and how, through the action of the cochlea, the differences between them are appreciable to the human ear. Modern research has abundantly confirmed his belief that the nerve-endings at the lower end of the cochlea, the "basal turn," on the left-hand side of the diagram given above, are those which make it possible to hear high notes. Those at its upper end, "the apical turn," shown at the right-hand side of the diagram, are indispensable to the hearing of low notes. It has been shown that both in human beings [2] and in animals [3] destruction of the nerve-endings in one part of the cochlea is associated with deafness over a corresponding range of frequency or pitch.

The results of recent investigations confirm also the utility of pure-tone tests for accurate measurements of hearing. If sound over a given range of pitch can be heard at all, the corresponding portion of the cochlea must be able to function. There is another factor, of course, which often accounts for diminished auditory acuity, although not for total deafness, namely middle-ear defect. The middle ear, fortunately, is accessible to the otologist's inspection with lamp and mirror. He has also his series of diagnostic tests, named after their originators, such as Rinne and Schwabach. The discussion of these tests lies outside the scope of this book, but it may be said in passing that they can be carried out efficiently with a pure-tone audiometer.

In the lengthy investigation at Johns Hopkins Hospital, Baltimore, which has already been mentioned, particular attention was given to inner ear and nerve deafness. Measurements of the hearing of many patients during life were correlated with the results of examination of their ears after death. The result was further to confirm the established view that inner-ear defects are usually followed by greater deafness to higher than to lower tones. A loss of acuity exceeding

[1] See Luciani, L., translated by Welby, F. A., 1917, *Human Physiology*, iv, 218-65.

[2] Crowe, S. J., Guild, S. R., and Polvogt, L. M., 1934, "Pathology of High-tone Deafness," *Johns Hopkins Bulletin*, 54, p. 315.

[3] Hallpike, C. S., 1935, "Recent Advances in the Electro-physiology of Hearing," *Journal of Laryngology and Otology*, 50, pp. 672-87.

60 decibels at 4096 vibrations per second was found to be almost invariably associated with a partial atrophy of the nerve supplying the basal turn of the cochlea.

It will be noticed that electrical apparatus, a pure tone audiometer, was used in the tests at Johns Hopkins Hospital. The new era in the physics of sound, which followed the development of the thermionic valve, led to advances in methods of making pure-tone hearing tests in two directions.

In the first place, physicists and workers in telephone research laboratories became intensely interested in problems relating to human hearing. For these and other purposes they designed and built electrical apparatus capable of producing sound of any frequency audible to the human ear, at levels of intensity which can be varied and exactly controlled by the turn of a dial, which regulates the amount of current passing through the receiver.

With a tuning-fork the loudness of the sound produced can only be known as the result of careful calculation and considerable skill. With electrical apparatus sound can be maintained at a fixed level of loudness for as long as may be desired, and interrupted or repeated at will. By contrast the sound of a tuning-fork is continuously decreasing in loudness from the instant it is struck, and it is no easy task for a listener to decide the moment at which it ceases to be audible. The difficulties in the manipulation of high-pitched forks are such that supplementary instruments, e.g. the stringed monochord and the Galton whistle must be employed. Finally not only does modern electrical equipment cover the whole range of frequency or pitch needed for the effective measurement of human hearing but it is also capable of producing sound at the very high levels of loudness, quite beyond the reach of tuning-forks, which are required for thorough tests of very deaf patients.

Step by step apparent objections to the use of electrical apparatus of the audiometer or beat-tone oscillator type, for the measurement of human hearing, have been explained or have proved to be groundless. For instance, the Royal Society of Medicine Committee for the Consideration of Hearing Tests, in their report published in 1932, suggested that when the patient listens through a telephone receiver "conduction by air, bone and cartilage are all brought into

play," and again, "In all cases there may be cartilage conduction which will cause error in the results of testing."

Since then, however, experiments have been carried out by the Western Electric Co. to determine the vibration at the periphery of the telephone cap when the telephone is emitting a low note at its maximum intensity.[1] The vibration was found to be 17-20 decibels below the threshold of bone-conducted perception. It could not therefore cause the listener to hear sound.

The cause of a further apparent difficulty raised in the Royal Society of Medicine Report already quoted has also been explained. The report stated: "As oscillometers the present audiometers are scientifically accurate. It is in their application to clinical otology that they have failed, in that results obtained differ from those obtained from tuning-forks."[2] That this statement does not hold good from the point of view of the otologist has been well shown by Hallpike.[3]

Measurements made by Kerridge[4] indicate that differences between the results of tuning-forks and audiometer tests are mainly due to extraneous noise[5] and occur chiefly over the upper half of the speech-frequency range (i.e. on frequencies upwards of 512 vibrations per second). The largest mean difference was of the order of 21 decibels at 1024 vibrations per second. When made with moderately or severely deaf subjects the tuning-fork test was found to be more affected by extraneous noise than the audiometer tests. Both tests were affected with slightly deaf subjects. The experimental error of the tuning-fork test proved to be most marked on upper frequencies (e.g. at 2048 vibrations per second) owing to the rapid decay of the sound, "so that a few seconds indecision about the faintest sound caused significant error."

Littler[6] has pointed out that where audiometer tests are

[1] Kerridge, P. M. T., 1937, "Hearing and Speech in Deaf Children," *Medical Research Council Report*, p. 15.

[2] P. 15.

[3] Hallpike, C. S., 1933, "Critical Review of the Hearing Tests Committee Report," *Journal Laryngology and Otology*, **48**, 2, p. 118.

[4] "Hearing and Speech in Deaf Children," pp. 55-8.

[5] See also Knudsen, V. O., and Jones, J. H., 1935, "Basic Principles Underlying Tests of Hearing," *Laryngoscope*, **45**, pp. 10-14.

[6] Littler, T. S., 1936, "Hearing Aids for the Deaf," *Journal of Scientific Instruments*, **13**, pp. 144-55.

made as a basis for advice about the use of hearing-aids the employment of a telephone receiver is not only unobjectionable but even desirable if the aid is of air-conduction type and itself embodies a telephone receiver.

To sum up, it may be said that of the two chief methods of measuring deafness, the first, the pure-tone method, is analytical and is used to find the sensitivity of the patient's ear to sound of different frequencies, either by air or by bone conduction. The kind of stimulus used is rarely if ever met in daily life, but its chief justification is in the structure and behaviour of the ear itself, especially of the cochlea. The second form of test is by means of the actual sounds of speech. In such tests the listener's powers of sensory discrimination and his intelligence, temperament and previous education and experience are inevitably involved to a greater extent than in pure-tone tests. But when the results are to be used as a criterion of the patient's need of alleviation or as a basis for advice on the use and choice of hearing-aids, this inclusion of factors not purely auditory is both necessary and desirable.

In the study of deafness two limits to the sense of hearing are of the greatest practical importance. These are limits of intensity. There is for any sound a level of loudness at which it can just be heard and below which it is inaudible. This limit is commonly known as the threshold of audibility. The other limit of intensity, which has only been investigated in recent years, is that level of loudness at which sound begins to cause physical discomfort. If the loudness is further increased it may even result in sensations of sharp pain. This threshold has been given the name of the threshold of feeling.[1]

The scale now universally adopted by physicists and engineers for the measurement of the intensity of sound is the decibel scale. It is already so widely known as to be familiar to many non-professional readers of the daily press. It is based on the amount of current required to produce the sound by means of standardised electrical apparatus.

To calculate averages or means of normal hearing it is necessary to test a large group of persons who may be considered as typical. The procedure adopted by Bell Telephone

[1] Wegel, R. L., 1922, "The Physical Examination of Hearing and Binaural Aids for the Deaf," *Proceedings of the National Academy of Science*, 8, p. 7.

Laboratories in their main investigation was to measure the thresholds of audibility of 102 ears of men and women. After the tests an otological examination showed that some of the subjects had defects in their hearing. All doubtful cases were eliminated and the results on 72 ears remained.

It may be asked whether there are differences in hearing typical of age, sex, environment and occupation. At present the first answer must be to reiterate the plea, already urged in Chapter I, for increased facilities for the measurement of hearing and widespread use of them by the public. The evidence already available will be discussed below. It suggests that the significant differences in individual losses of hearing which constitute deafness are those due to health history, disease and injury, and that, by contrast, differences due to age are of less importance, at any rate before the age of 50 years.

The following diagram illustrates the limits of normal hearing by air conduction, as determined by Bell Telephone Laboratories. The tests were, of course, made in sound-proof rooms. The age of the subjects was 18 to 23 years.[1]

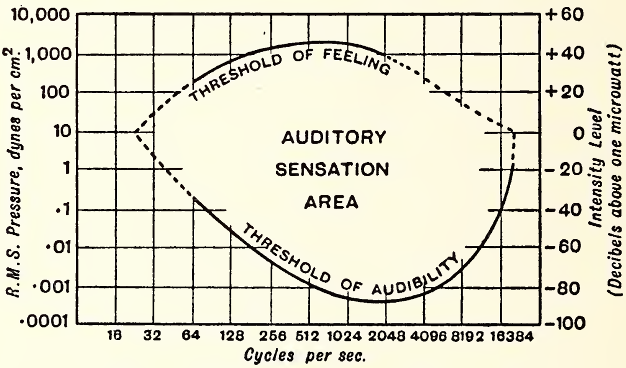


DIAGRAM 12.—Limits of normal hearing.

(Fletcher, 1929, p. 141 ; courtesy of D. van Nostrand Company, Inc.)

The practical implications of this diagram are as follows. On the right is a decibel scale of intensity. The normal listener is most sensitive to sound at the frequency of 2048 vibrations per second (bottom line), three octaves above middle C on the piano. At this level of pitch he can hear a very weak

[1] "The 6A Audiometer," 1936, *Western Electric Co. Bulletin.* See also Montgomery, H. C., 1932, "Do Our Ears Grow Old?" *Bell Telephone Laboratories Record,* 10, 9, p. 311.

sound, for the production of which a minute current, technically more than 80 decibels below 1 micro-watt, is sufficient. The normal human ear is less sensitive to sound lower or higher in frequency than 2048 vibrations per second. It is not aware of sound of 128 vibrations per second (one octave below middle C) if the intensity is more than 45 decibels below 1 micro-watt. Because of this low-pitched tones produced by such musical instruments as the organ and piano are considerably more intense than those produced in the high-pitch range.[1] On the left-hand side of the diagram measurements are given of the atmospheric pressure on the ear at each level of intensity.

The loudest sound which the normal listener can endure without physical discomfort was found by Wegel to be at the frequency of 1024 vibrations per second. The threshold of feeling shown on the diagram was determined by measurements of 48 normal ears.

That part of each threshold where the line is dotted was calculated and no measurements were actually made over the corresponding range of frequencies.

Perhaps the most striking feature of the hearing capacity of the normal listener is the immense range of intensity between the threshold of audibility and the threshold of feeling. It is common knowledge that in broadcasting music the engineer in the control-room reduces the intensity of the loudest passages, which might otherwise overload some of the electrical equipment. Yet the players and the audience listening normally in the concert-hall are able to endure these same loud passages without any discomfort.

From the diagram it will be seen that at the frequency of 1024 vibrations per second the range of intensity between the threshold of audibility and the threshold of feeling of the normal listener is one of 130 decibels. The decibel scale is logarithmic. Arithmetically expressed this range corresponds to a ratio of 10 billions to one. Detailed study of the effects of its limitation through defects of hearing is necessary to the understanding of deafness.

The above diagram is found to be an inconvenient form of chart for entering the results of individual listeners. Thresholds of audibility are commonly entered on charts called

[1] Fletcher, Harvey, 1929, *Speech and Hearing*, p. 98.

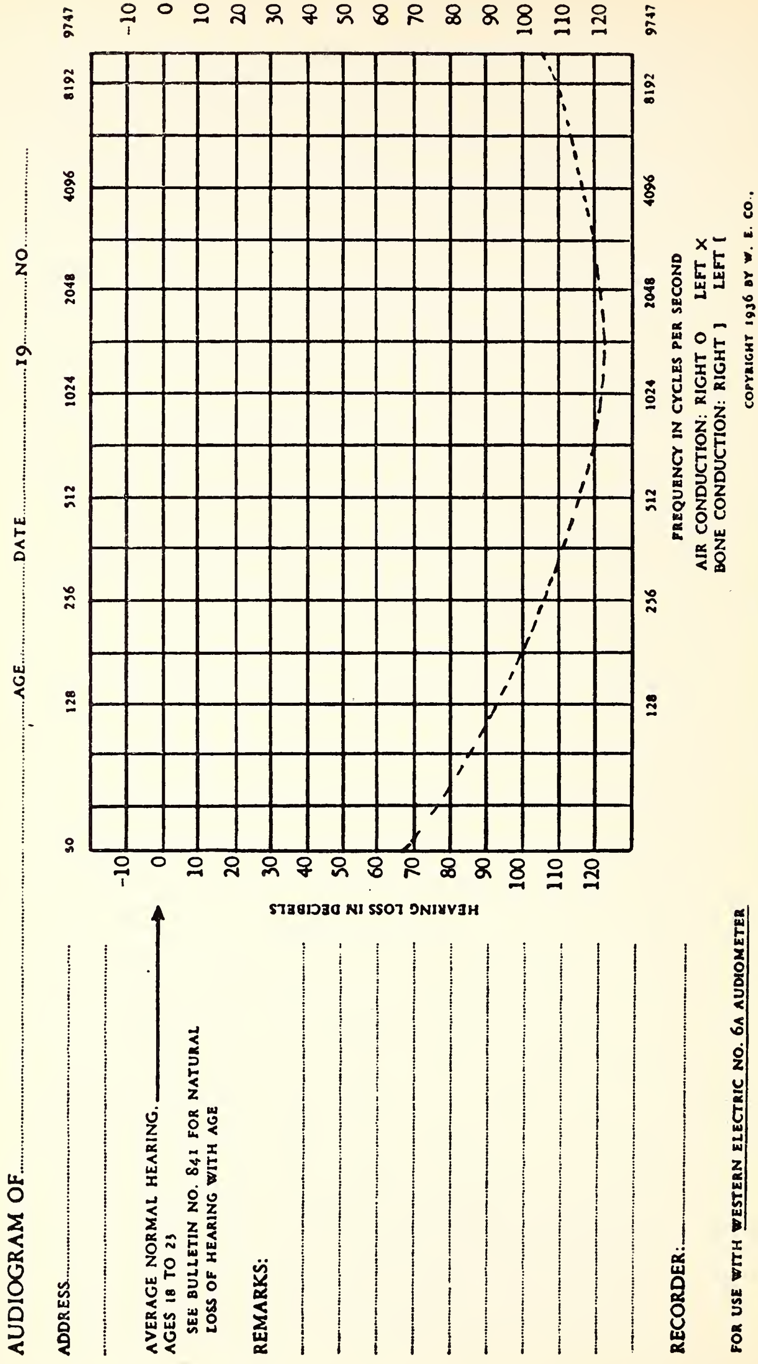


DIAGRAM 13.—6A Audiogram blank.

audiograms in which the intensity scale reads downwards and in which the normal threshold of audibility is shown as zero. Diagram 13 is an example of the audiogram blanks supplied by the Western Electric Co.

The limits of hearing by bone conduction have not yet been fully explored. Normal thresholds of audibility for clinical use have been calculated, but in the case of electrical apparatus are at present dependent upon the type of receiver used. It is clear that stimulation of the normal ear by bone conduction involves the expenditure of considerably greater energy than is needed by air conduction, but so far as is known to the writers, measurements to determine the exact ratio have yet to be made. No upper limit or threshold of feeling for sound heard by bone conduction appears to be available. At frequencies below 256 per second, vibrations of the skull can be felt at intensities less than those needed to stimulate the cochlea and to give rise to sensations of sound. We have found that the production of very loud sounds with a bone-conduction receiver entails discomfort through jarring of the skull and excessive pressure on the skin.

CHAPTER VI.

DETECTION AND ASSESSMENT OF DEAFNESS.

Changes in hearing due to age.

An early account of comparative audiometric measurements of the hearing of persons belonging to different age groups and free from ear disease was published at Iowa University in 1922. There Zuehl [1] tested 275 individuals, of whom a minority, 25 in number, were aged 42 to 73 years. This group proved to have less good hearing for high-pitched sounds, especially above 6000 vibrations per second, than the groups of children and younger people. Zuehl concluded, however, that "events in health history have a higher correlation with variations in hearing ability than the latter have with chronological age."

Diagram 14 on the opposite page shows the median value for the loss at each frequency obtained by tests made by Montgomery [2] in Bell Telephone Laboratories of 185 individuals belonging to four age groups.

It is thus necessary to take the patient's age into account when making pure-tone measurements of his hearing. Patients of 50 years of age should be compared with normal listeners belonging to their own age group and not with those of 18 to 23 years for whom the zero line on the chart represents the average threshold of hearing.

It will be seen that a progressive falling-off in acuity with increasing age was clearly proved. This loss of acuity due to age was confined, however, to hearing for sound higher in pitch than 2048 vibrations per second, and by contrast with the loss of hearing found among deaf patients and illustrated throughout this book it is of a very slight character. While emphasising this latter point Montgomery concluded that although in conversation the group of persons aged 50 to 60

[1] Zuehl, B. F., "Measurements of Auditory Acuity," *Psychological Monographs*, 31, p. 1.

[2] Montgomery, H. C., 1932, "Do Our Ears Grow Old?" *Bell Laboratories Record*, 10, 9, pp. 311-13.

years would not notice their falling-off at the high frequencies, they " might experience some difficulty in distinguishing consonant sounds, and mistake ' thin ' for ' sin,' ' famish ' for ' vanish ' " in the theatre or lecture hall. There " the

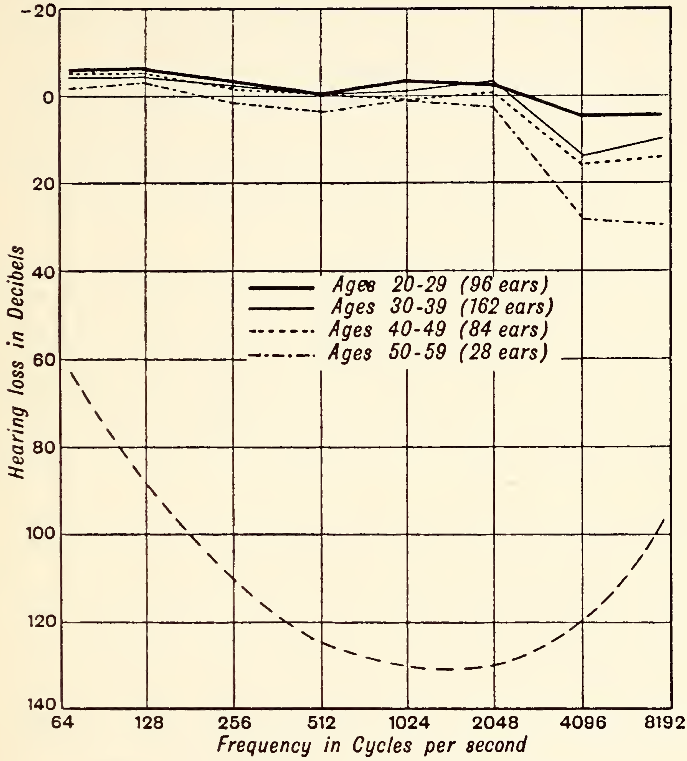


DIAGRAM 14.—Changes in hearing due to age.

level of sound at the ear is often quite low " and " the higher frequency components are usually weak by the time they reach the ear, due to selective absorption in the room."

Montgomery's figures in detail are :

	Frequency.			
	60—1024	2048	4096	8192
	Hearing loss in decibels.			
Ages 20-4 (96 ears) . .	0	0	6	6
„ 30-9 (162 ears) . .	0	0	16	11
„ 40-9 (184 ears) . .	0	2	18	16
„ 50-9 (28 ears) . .	0	5	30	32

Knudsen and Jones [1] made tests to determine the lowering of the upper limit of hearing for frequency. They say : " In our clinical experience we have found only one person who could hear above 20,000 cycles. . . . The average human being with normal hearing does not hear higher than about 18,000 cycles. . . . When one attains an age of 35 or 40 years the limit is down to approximately 15,000. When one has attained an age of 55 to 65 years the average normal limit is approximately 10,000 to 12,000 ; those who have reached an age of 70 or 75 years rarely hear above 8000 cycles. There is this sliding scale for the normal, based solely upon age."

Pure-tone audiometers and oscillators.

The design and construction of apparatus for making pure-tone measurements of hearing are outside the scope of this book, but experience proves that the clinical worker needs to understand certain facts about its character and management. The writers would like to emphasise that ten years' use of audiometers has shown that very reliable instruments can be bought which give little or no trouble over long periods.

Essential features of a reliable audiometer are as follows :

Reliability as to the *pitch* or frequency of the sounds produced. Some instruments have an arrangement for tuning the pitch of their output at one or more frequencies, with the help of a tuning-fork held to the ear or by a mechanical device. The clinical worker, often pressed for time, naturally prefers an instrument which needs no tuning, but even so a periodic check with a tuning-fork is usually advisable. The physical fact is very helpful that two sounds which differ slightly in pitch (e.g. sounds of 128 and 130 vibrations per second respectively) cause " beats." The production of more than a very small percentage of *overtones* or harmonics may render audiometer tests ineffective. Patients severely deaf at different levels of pitch may hear and respond to overtones when they cannot hear the fundamental test tone itself. (Compare explanation of use of complex sounds for hearing tests, p. 97.)

The *limits of pitch* required for effective measurements of hearing over the whole of the speech range are approximately from 90 to 8000 vibrations per second. The minimum range

[1] Knudsen, V. O., and Jones, J. H., 1935, " Basic Principles Underlying Tests of Hearing," *Laryngoscope,* 45, 1, pp. 7-8.

needed to test hearing for speech is from 250 to 5000 vibrations per second.[1] Guild and his collaborators at Johns Hopkins Hospital, Baltimore,[2] have shown that tests at 4096 vibrations per second are critical for diagnosis. Some instruments give a *continuous frequency range*, others provide a limited number of *representative frequencies*. It is an undoubted advantage to be able to find the upper limit of pitch at which patients can hear, especially if they suffer from severe deafness to high notes. Ordinarily, however, and without unduly prolonging the examination, it is only possible to test at selected frequencies. In our work the results of tests in which half octave and other intervals have been used have rarely added information not already obtained by tests at octave intervals—at 128, 256, etc., vibrations per second. For bone-conduction tests Jones and Knudsen recommend testing three frequencies only, 128, 512, and 2048 vibrations per second.[3] In our procedure the selected frequencies for bone-conduction tests are 256, 1024 and 4096 vibrations per second, the frequency 128 being avoided because, at large intensities, it causes vibrations that can be felt.

It is strongly desirable that instruments for pure-tone testing should be calibrated in decibels for intensity. No other scale of loudness units is so widely used by workers of every kind. Its employment in hearing tests is the bedrock upon which international standards of hearing are becoming established. It makes possible interpretations of the results of individual measurements of hearing in terms of the loudness levels of speech and other sounds.[4] Periodic checks are advisable to detect changes in intensity values which may be caused by mechanical changes or defects in the instrument. These are best made with practised normal listeners in a sound-proof room or in conditions which are at least very quiet. Even in a quiet country house there may be 10 decibels of extraneous noise which will tend to render the results of tests of normal listeners inaccurate.

[1] Ewing, Ewing and Littler, 1936, "The Use of Hearing Aids," p. 31.

[2] Crowe, S. J., Guild, S. R., and Polvogt, Z. M., 1934, "Pathology of High Tone Deafness," *Johns Hopk. Hosp. Bull.*, 54, p. 315.

[3] Jones, J. H., and Knudsen, V. O., 1935, "Diagnosis of Deafness," *Laryngoscope*, 45, 1, p. 29.

[4] See p. 103.

With battery instruments strict attention to the upkeep instructions given by the makers is of course essential, to ensure constancy in frequency and intensity and to avoid the noise which may be caused by a defective or run-down battery. Apparatus working from a *mains supply* should be free from inherent noise or " mains hum " which may occur if there are defects in component parts of the smoothing system.

Quiet room needed for tests.

The use of a telephone receiver in making pure-tone measurements, by covering the ear, reduces the loudness of outside sound in the ear tested by about 10 decibels. Thus it protects the listener, to some small extent, from interference by extraneous sound. Any noise which he can hear may mask the test-sounds or distract his attention. For typical loudness levels of noise the reader is referred to Diagram 23 given on page 103. The loudness of noise in a room may be measured at different frequencies with an audiometer by the balancing method. Intermittent sounds that are of fairly regular occurrence should be noted. It will be found that noise audible to the listener may mask test sounds of equal, higher and, to a lesser extent, lower pitch.[1] Jones and Knudsen write : " The amount of noise present in the average otologist's office in a metropolitan location is rarely less than 25 to 30 decibels. In many offices the noise is at a level as high as 40 or even 50 decibels. If one listens to the tones produced by tuning-forks in such rooms, the tones from the forks do not become inaudible at the minimal threshold of audibility ; they become inaudible at the threshold of the noise present in the room—that is, when the tone can no longer be heard because of the noise. Unless, therefore, the patient cannot hear the noise in the room, what one measures is not the amount of hearing the patient has, but rather the amount of noise which is present in the room." They go on to urge that if the noise factor is ignored patients with 30 per cent. loss of hearing may appear to be normal and they ask, " Is it not just this type of case in which we can give the most help by instituting measures to prevent deafness ? "

[1] A non-technical explanation of masking is given by Beatty, R. T., 1932, *Hearing in Man and Animals*, pp. 92 and 207. G. Bell & Sons Ltd.

Procedure in making pure-tone audiometer tests.

Individual tests of the threshold of audibility of deaf patients, in which the response of each ear is measured separately on six frequencies, usually take from fifteen to twenty minutes when the following procedure is adopted. Bone-conduction tests require proportionately more time according to the number of frequencies tested.

The essential feature of this procedure is that it is an " all or none " method. The judgment which the listener is asked to make is " Yes " or " No "—whether he hears or does not hear. This is not the same as to ask the listener to state when a sound decreasing in intensity has ceased to be audible. The writers believe, as the result of much experience in the laboratory, both as experimenters and as subjects, that the " Yes " or " No " type of test is both easier and more accurate in its results.

They have found that when a diminishing sound is employed at loudness levels near the listener's threshold of audibility he is apt to mistake the change from a larger to a smaller intensity for a change from hearing to silence. After several seconds in which a process of adaptation seems to take place, he finds that the sound " is still there after all." All this is a source of hesitation and delay which it is desirable to avoid.

The procedure here recommended is therefore based on presentations of the test sounds to the listener for periods variable in length, alternating with periods of silence, which also are sometimes longer and sometimes shorter in duration.

Many makers of audiometers provide a lamp signal to be switched on or off by the listener when he hears. This obviates any need for the listener to speak during the test and enables him the more fully to concentrate his attention and to accustom his mind to very weak sound. Even his own voice may act as a distraction. Occasionally elderly patients find the management of the lamp signal a troublesome complication and do better if asked simply to say " Yes " or " No." Tests of young children will be discussed later.

The usual instructions to the listener therefore are : " Press (or release) the switch when you hear any sound in the telephone, however weak," and " Do not press (or release) the switch until the sound stops." The operator must take

precautions, with some instruments, to avoid causing clicks in the telephone receiver through "breaking and making" electric circuits in the apparatus.

A particular frequency is selected. It is first presented to the listener at a loudness level at which it can easily be heard, say 50 decibels above normal threshold for a slightly or moderately deaf patient, 70 or more decibels for one who is severely deaf. The sound is maintained for several seconds at the same intensity, then cut off. A period of silence follows. The same frequency is then repeated at a lesser level of loudness. This process is continued, with alternating periods of sound and silence, until a level of loudness is reached at which the listener ceases to respond because he can no longer hear.

Before recording any measurements the operator makes certain, through practice, that the listener understands what is required and is responding, as promptly as his general habit of mind will permit, to the onset and disappearance of the test sounds. The amount of practice needed varies according to the patient. It should include trials at not less than two frequencies, say 1024 and 256 vibrations per second, and should end at an intensity level which is approximately the threshold of audibility of the individual listener.

During the preliminary practice it sometimes helps to remove any lingering apprehensions in the minds of nervous patients if they are allowed to watch the manipulation of the instrument. During the test proper the listener should be so placed that he cannot see these movements, otherwise his mind instinctively seeks for some incidental clue which will help him to recognise the sound's occurrence.

The reliability of the test results are thus ensured in two ways. First, the listener's signal should follow promptly upon the onset or cessation of the sound. If the timing of his reactions fails to coincide with these, or if he responds for instance during what is actually a period of silence, it is necessary to re-test him at a louder intensity. Secondly, repetitions of the same frequency at the same intensity, with longer or shorter duration, should give precisely the same accuracy of response. In no other conditions can the response be held reliable. It is usual to repeat the test at each frequency, not only at the minimum loudness level at which the listener responds with certainty but also at the loudness levels immediately below

and immediately above. In the latter case response should of course be very prompt.

As already mentioned, a factor of adaptation is present in threshold tests. Most listeners are unaccustomed to the need for reaction to sounds at intensity levels near the threshold of audibility. If preliminary practice is omitted the results of tests on the first frequencies tested will usually, on repetition, be found to have been unreliable.

The above procedure can be followed in making tests with either air or bone-conduction receivers.

The Western Electric Company supply additional equipment for making bone-conduction tests by a masking method. The patient listens with the bone-conduction receiver on the ear to be tested. At the same time he hears sound of the same pitch in the air-conduction receiver, which is held to the opposite ear. The sound in the bone-conduction receiver is interrupted and he is asked to signal when he perceives this to have happened. The operator notes the minimum intensity level at which the awareness of fluctuation can be produced. It is believed that this device is effective in cases where there is disparity in acuity to sound, heard by bone conduction, between the two ears.

Care needs to be exercised to see that in air-conduction tests the telephone is held firmly but without undue pressure on the ear.[1] For bone-conduction tests the earlier armature type of receiver [2] had the advantage that the operator could select as the point of contact a region where the minimum of other tissue intervened between the instrument and bony structure. He could also use the amount of pressure suited to give the best results. With the smaller reed type of bone-conduction receiver, especially when worn by the patient on a head-band, there is not the same opportunity for control of these factors by the operator. Since they necessarily influence the results of the test, especially on lower frequencies, it is advisable to find by preliminary trial in what position and with what degree of firmness the receiver is best applied.

[1] A sponge rubber washer, on the telephone cap, is used by the Western Electric Company and facilitates effective sealing of the cap to the ear.

[2] Such as the Western Electric Company's bone-conduction receiver, No. D-80904.

It is convenient, when following the above procedure, to enter all the readings obtained at each frequency on a prepared form and subsequently to transfer the final results to an audiogram or chart.

Hearing curves of typical patients.

To illustrate the nature and value of results of the measurement of hearing for pure tones, by the methods already described, the audiograms [1] and histories of four typical adult patients are given. These patients, amongst others, gave their services over a considerable period in an investigation carried out in our laboratory. They became highly practised listeners. The object was to compare hearing for pure tones with hearing for speech. The amount of help obtainable from the use of hearing aids of different types was also determined.

The otological and medical examinations were made by the honorary otologist to the Department of Education of the Deaf, Mr. V. F. Lambert, F.R.C.S. The results for the better ear of each patient are given.

(1)

Reference No. T. 2 (Diagrams 15 and 16).

Age : 22 years. Deafness for six years ; came on gradually ; right started before left.

Summary of audiogram :

(*a*) Air conduction : considerable deafness to lower and middle tones. Upper tones less affected.

(*b*) Bone conduction : normal acuity for lower tones, appreciable loss in middle of range.

Previous medical history. Scarlet fever, measles, mumps. No ear complications at time of illness. Family history of deafness on father's side. Both drums are normal. Tonsils still present. No adenoids. Nasal airway good. Rinne's test negative.

Bone conduction (fork test) prolonged. Slight improvement of hearing on inflation. Probably a chronic catarrhal deafness.

Patient's speech : normal.

Hearing for speech. This patient was a University student. He had some ability to follow mf. conversation with the unaided ear but found it difficult to carry on intercourse in ordinary daily life and impossible to follow lectures. By using a portable valve aid of a type designed by Littler,[2] and also as the result of a course of lipreading lessons, an immediate

[1] The audiograms are those of each patient's better ear.

[2] Littler, T. S., 1936, "Hearing Aids for the Deaf," *J. Scientific Instruments.*

and marked improvement in his academic work took place. At the end of his University course he took a good degree and obtained an appointment with an industrial firm.

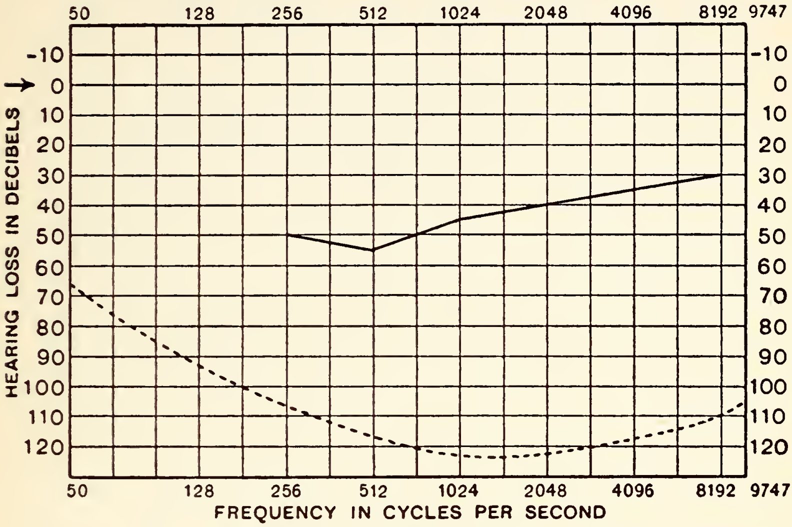


DIAGRAM 15.—Patient T. 2. Air conduction.

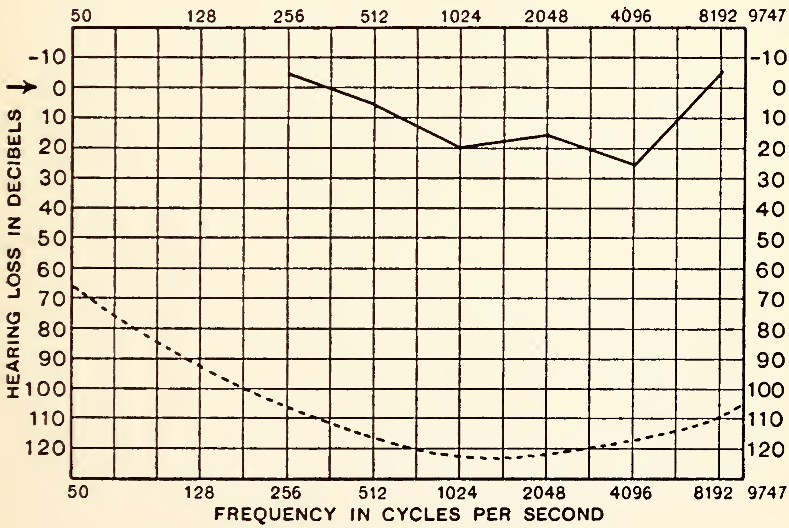


DIAGRAM 16.—Patient T. 2. Bone conduction.

(2)

Reference No. S. 3 (Diagrams 17 and 18).

Summary of audiogram :

(*a*) Air conduction : marked loss for all frequencies, severe at and above 4096 ~.

(*b*) Bone conduction : slight deafness at and below 512 ~ : greater for middle and upper frequencies.

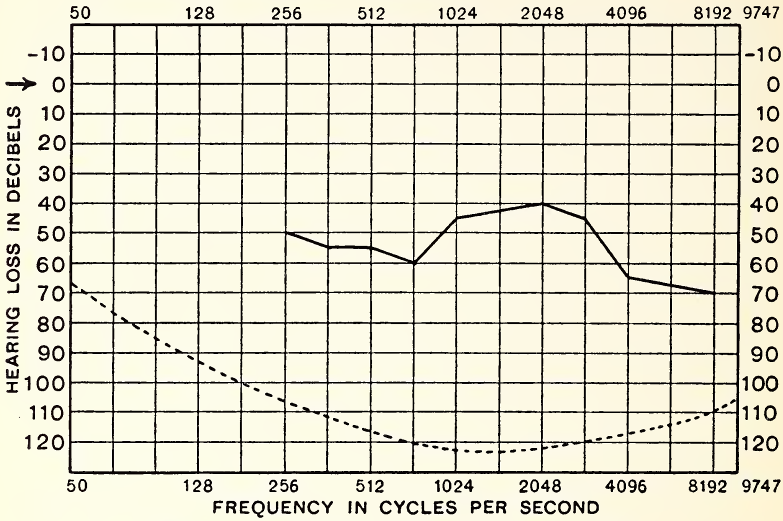


DIAGRAM 17.—Patient S. 3. Air conduction.

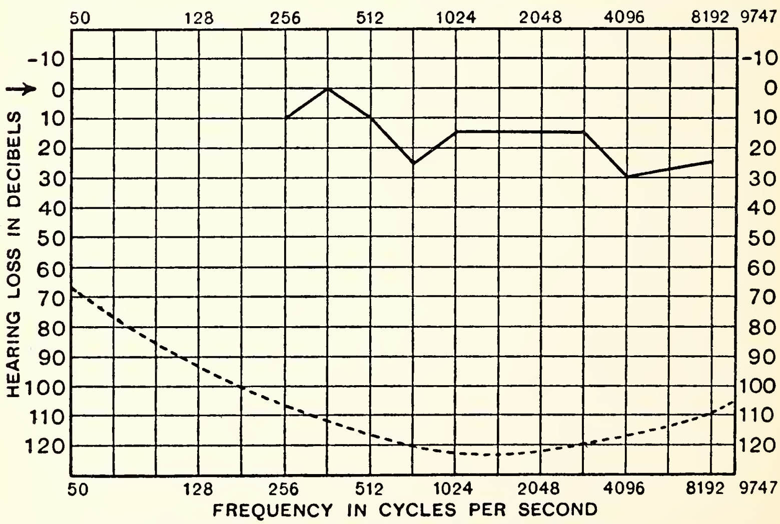


DIAGRAM 18.—Patient S. 3. Bone conduction.

Age : 25 years. Deafness observed at 18 years. Tinnitus (" head noises ") very severe. One aunt deaf.

Previous medical history. Whooping-cough, measles, chicken-pox, rheumatism. No gross disease in nose or nasal pharynx. Tonsils present, not septic. Drums normal. Rinne's test negative. Typical case of otosclerosis.

Patient's speech : normal.

Hearing for speech : with unaided ear and without lipreading could understand, to some extent, f. speech at short distance if distinct and confined to familiar phrases. In daily life, however, she experienced considerable difficulty and strain as the result of her deafness. She was a married woman, living at home. Attendance at classes in lipreading brought about alleviation. With the experimental valve amplifier already mentioned she was able, when speech was amplified to high levels of loudness, to hear vowels and consonants with 100 per cent. accuracy. Was unwilling, nevertheless, to use regularly a portable valve amplifier or any aid, although convinced as the result of the tests that such an instrument was capable of giving her very much help.

(3)

Reference No. D. 2 (Diagrams 19 and 20).

Summary of audiogram :

Air and bone conduction : severe loss for all frequencies tested, greatest in middle of range.

Age : 18 years. Deafness on both sides of family.

Gradual onset for ten years. Tonsils and adenoids removed eight years ago. Paracentesis right ear eight years ago.

Previous medical history. Influenza eight years ago, deafness appears to have followed this. No history of measles or scarlet fever. No changes in drums. No gross disease in nose or nasal pharynx. Both Eustachian tubes patent. Weber's test not lateralised. Rinne's test negative both sides. Bone conduction (fork test) diminished both sides.

Patient's speech : when first tested was often monotonous, " heady " and lacking in resonance. Pronunciation of consonants, especially of sibilants, was defective.

Hearing for speech : with unaided ear could hear no sound except ff. voice within 3 feet from the ear. Attended a school for normal boys up to the age of 16 years but became markedly backward in spite of good ability. Subsequent individual tuition by lipreading and with hearing-aid apparatus led to very good all-round progress in speech and school subjects. In daily life this patient now relies on lipreading, supplemented by a portable hearing-aid. The results of laboratory tests showed that for him speech reaches maximum intelligibility when amplified to a loudness level of 110 phons, i.e. considerably greater than that of noise in boiler-shops and weaving sheds. When tested at this level his score was 100 per cent. for vowels, and 90 per cent. for consonants.

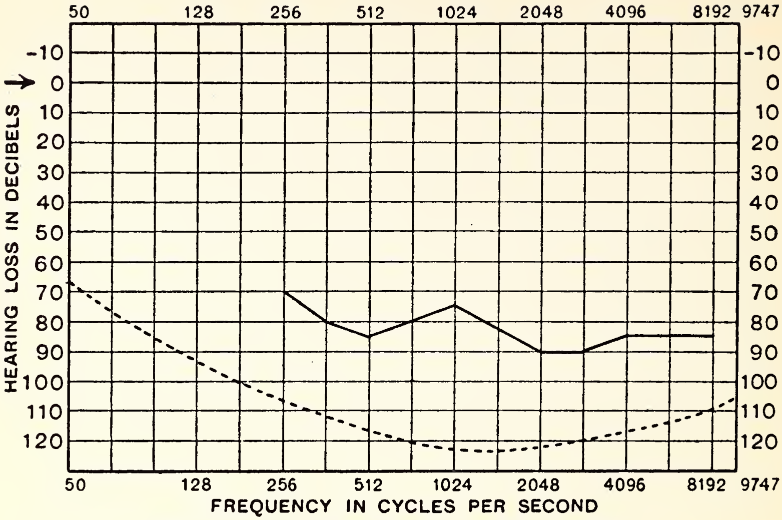


DIAGRAM 19.—Patient D. 2. Air conduction.

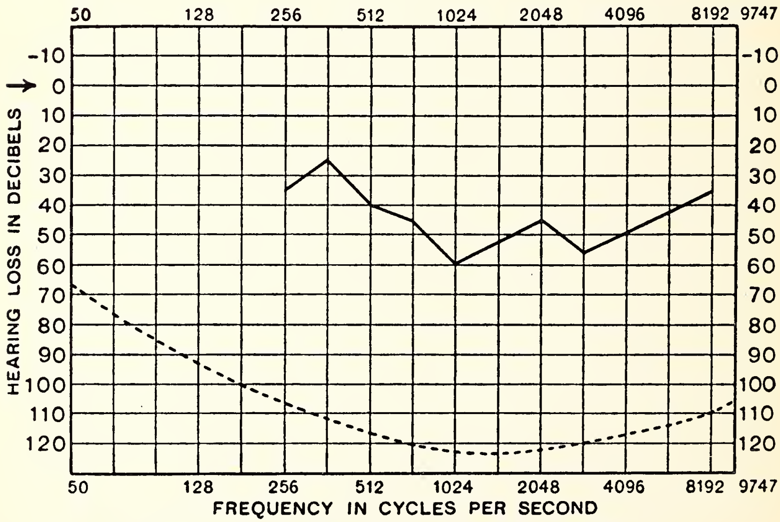


DIAGRAM 20.—Patient D. 2. Bone conduction.

(4)

Reference No. C. 3 (Diagram 21).

Summary of audiogram :

Air and bone conduction : very severe deafness.

Age : 60 years. Increasing deafness for thirty years, right ear became deaf first, followed shortly after by left. Right ear is now the better ear for hearing. No tinnitus. Used to have attacks of vertigo, but none now. No change at present obvious in right drum. No gross disease in nose or nasal pharynx.

Medical history : No serious illness at all. Weber's test not lateralised. Rinne's test negative both sides.

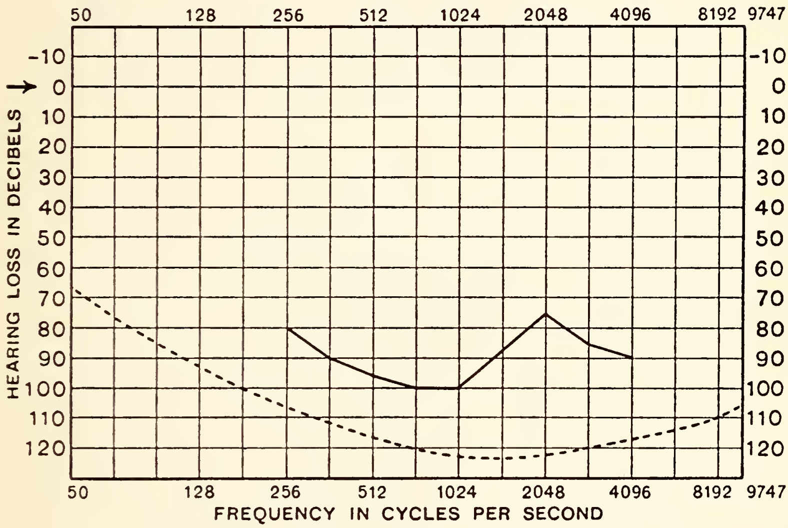


DIAGRAM 21.—Patient C. 3. Air conduction.

Bone conduction (fork test) diminished both sides. Both Eustachian tubes patent.

Patient's speech : intonation monotonous and voice deficient in resonance.

Hearing for speech : with the unaided ear and without lipreading could only recognise familiar phrases uttered in an ff. voice at distances not greater than 1 foot from the ear. Now depends mainly on lipreading supplemented by such help as he can get from the portable aid which he habitually uses. Suffered from severe deafness for many years before learning to lipread and at first progress in acquiring the habit was slow and difficult. In the standardised speech tests the best results were obtained at a very high level of loudness—100 phons. Vowel score was then 65 per cent. and consonant score 25 per cent. The lowness of these scores was not due to failure in mental perception but to the fact that even at

100 phons speech was only 20 phons above his threshold of audibility, i.e. its loudness to him was relatively less than that of a whisper to a listener with normal hearing.

Detection and measurement of deafness in children.

The problem of the detection and measurement of deafness in children may be summarised under three heads :

(*a*) the process of combing-out the normal school population in order to detect children with defective hearing ;
(*b*) subsequent individual examination of individuals ; and
(*c*) detection and assessment of deafness in infants and children of pre-school age.

Tests suitable for the third of these purposes are discussed in Chapter VII.

Group tests of hearing.

The apparatus known as the gramophone audiometer was designed and constructed in Bell Telephone Laboratories, New York,[1] and is now extensively used by school medical officers and other workers in America and Great Britain. It consists essentially of a mechanically operated turn-table, electro-magnetic pick-up, a single pilot-telephone (which can be used for individual testing) and one or more trays of eight single telephones each. No electric mains supply or batteries are needed. All the telephones in each tray are permanently wired to a single plug, and the insertion of this in the appropriate jack on the main instrument or on another tray connects all the telephones to the pick-up in one operation.

The maximum number of telephones which can be connected, and therefore the maximum number of individuals who can be tested at one time, is forty. The same record is used twice at each test, once for the right and once for the left ear, the total time required being 15 to 20 minutes. It has been found that approximately 100 individuals can be tested per hour. Each person to be tested is provided with a printed form, of which the following is a sample[2] :

[1] Fletcher, H., *Speech and Hearing*, pp. 212-13.

[2] The writers are indebted to Mr. A. G. Wells, Principal Assistant Medical Officer of the London County Council in charge of the aural work of the school medical service, for permission to use his modified test which has become available since this book went to press.

When the supervisor has made sure that every one is ready, and in particular that all the telephones are properly adjusted on the ears, the record is played. A male voice is heard in the telephone saying : " You are now going to have your

G.P.H. 86

London County Council

PUBLIC HEALTH DEPARTMENT.

Test No.............................

Date...................................

AUDIOMETER

School.. Standard...................................

Name of Child.. Age......................

Hearing Level	RIGHT EAR		LEFT EAR		Hearing Level
	1	2	1	2	
30					30
27					27
24					24
21					21
18					18
15					15
12					12
9					9
6					6
3					3
0					0
—3					—3
Hearing Level..................			Hearing Level..................		

Remarks :—

Diagram 22.

hearing tested. Listen carefully and write down the numbers which you hear in the first column." Single numbers follow in groups of three, e.g. " Four, five, one." Only the numbers " one " to " eight " are used. Each listener writes what he hears in the space provided on the form.

A record in which groups of two numbers only are spoken is available for testing younger children. As will be seen from the form the loudness of each successive group of numbers is decreased by 3 decibels. When the first column of numbers has been completed the voice is heard speaking at the initial level of loudness : " Now write the numbers which you hear in the second column." A different series of numbers follows, the intensity of each group being decreased as before in steps of three decibels. The rate at which the numbers are called is slower in the L.C.C. version than in the earlier records. It is advisable for the supervisor to instruct the listeners to fold their papers in such a way that they will not be tempted to refer to the right-ear results while the left ear is being tested.

The accuracy of each listener's completed form is checked by reference to a master sheet and to the scale printed in the extreme right and left-hand columns of the form. Ability to recognise two out of three numbers correctly at a particular loudness level during one of the four trials of each ear is counted as ability to hear at that level.

This test was originally standardised in America and subsequently in England by Crowden.[1] The loudness level taken as the norm and corresponding to " 0," when the apparatus is used as first planned, is that at which the majority of the children were successful in an average classroom with a typical background of noise. It is therefore necessarily higher than the threshold of audibility for normal listeners.[2] Ordinarily tests are made, as shown on the form, over a range of 30 decibels above the norm to 3 decibels below it. Recent models of the apparatus are equipped for testing up to eight listeners with louder speech, from 63 to 30 decibels and from 75 to 42 decibels above the norm.

The test was first adopted through the efforts of the American Federation of Organisations for the Hard-of-Hearing and in 1927 it was given to 250,000 school children.[3] Its use in England was begun at Hornsey by Crowden and Gale in

[1] Crowden, G. P., 1934, " Use of the Gramophone Audiometer," *Proc. R. Society Medicine*, 27, p. 428.

[2] See Chap. VI, p. 66.

[3] Fletcher, Harvey, *Speech and Hearing*, p. 213.

1929.[1] A "city-wide" investigation of 774,576 children has recently been made in New York City.[2] The report on this is of especial interest, not only because of the number of children included, all living in one city, but also because it gives evidence of the benefit obtained by those children classified as hard-of-hearing from subsequent instruction in lipreading.

Most published accounts of tests of school children with the gramophone audiometer lay emphasis on the number of children with defective hearing detected with its help and not discovered by other means. The organisers of the American investigation in 1927 concluded that from 8 to 12 per cent. of the children tested had defective hearing. Crowden and Gale found at Hornsey that 6·6 per cent. had defects in one or both ears, as compared with 0·42 per cent. shown in the annual returns for the routine medical inspection of elementary school children at that period. Further tests of children at Hornsey [3] and Tottenham, and in schools under the London County Council, led Crowden to a similar conclusion. The New York authorities found that 3·17 per cent. of the whole school population had impaired hearing in both ears, $4\frac{1}{2}$ per cent. were in need of otological diagnosis, and $1\frac{1}{2}$ to $3\frac{1}{2}$ per cent. had a hearing loss of 20 decibels or more, as proved by subsequent pure-tone audiometer test, and needed lipreading instruction.

On the other hand, it is reported [4] that among 30,000 children attending London County Council Schools only 42, or ·14 per cent., were detected by gramophone audiometer test as having defective hearing. This percentage is strikingly smaller than that given in the New York report. It is not accounted for by the number of London school children already in attendance at schools for the deaf and partially deaf, since these total 600 or approximately ·11 per cent. Adding this percentage

[1] Crowden, G. P., and Gale, A. H., "The Detection and Measurement of Deafness in School Children by means of a Gramophone Audiometer," *Medical Officer*, September, 1930, p. 113.

[2] Caplin, D., 1937, "A Special Report of Retardation of Children with Impaired Hearing in New York City Schools." Published in *American Annals of the Deaf*, May, 1937, pp. 234-43.

[3] *Journal of Laryngol. and Otol.*, 1934, **49**, p. 247.

[4] Wells, A. G., "An Estimate of the Incidence of Defective Hearing in England and Wales," *Brit. Med. Journ.*, July 3rd, 1937, pp. 18-20.

to that for children detected by gramophone audiometer test we get approximately $\frac{1}{4}$ per cent. London children with defective hearing, as contrasted with from $1\frac{1}{2}$ to $3\frac{1}{2}$ per cent. in New York with hearing sufficiently impaired to be in need of lipreading lessons.

Two conclusions seem to be justified. First, that all school children ought to be tested with the gramophone audiometer. The extension of the test to pupils in schools not under State control is urgently needed. Secondly, the need that in this rapidly developing field of work highly standardised methods should be established.

The chief problem is the detection, definition and subsequent educational treatment of what may be called " borderline " children. In New York all children showing 9 decibels or more loss on the gramophone audiometer test (failing at or before the loudness level corresponding to " 9 " on the printed form) were first of all retested with the same instrument. Those who still showed 9 decibels or more loss " were given an individual hearing test for both bone and air conduction in speech, and also complete tone ranges. The machine used was a 2A (pure-tone) audiometer. This individual hearing test is required for an adequate otological examination. An otological examination is given to all children showing a hearing impairment on the 2A (pure-tone) audiometer." The group test by gramophone audiometer was used solely for detection. The basis for diagnosis and subsequent educational treatment was an individual test with a pure-tone audiometer.

A tendency has been reported among " school medical authorities, who have obtained a gramophone audiometer in order to find out which of the children in the ordinary schools need medical attention for their ears, to use the same instrument for the more deaf children in their care, to save the further heavy expense of a pure-tone audiometer." [1] It would seem that this practice is to be avoided. A test based on called numbers is not, and was not intended to be by Bell Telephone Laboratories, a test of the intelligibility of speech as a whole. Numbers can be recognised correctly by patients with very little capacity to hear consonants, yet consonants determine

[1] Kerridge, P. M. T., 1937, " Hearing and Speech in Deaf Children," p. 51.

the intelligibility of ordinary speech to a much greater extent than vowels. This means, from the diagnostic aspect, that called numbers may fail to test hearing for upper tones to any appreciable degree of accuracy. By contrast a test with a pure-tone audiometer is precise for both lower and upper frequencies.

As regards subsequent educational treatment the dividing-line established in New York was, as already mentioned, based primarily on a hearing loss of 20 decibels or more in both ears as measured by the 2A pure-tone audiometer. From the children with this or a greater degree of loss, 93, or approximately 3 per cent., were recommended for admission to a school for the deaf. The remainder were retained in ordinary schools but given regular lipreading instruction, and when the report was written information was already available about the results of this treatment in the case of 4566 children. Prior to being taught lipreading 41·98 per cent. of these children showed retarded progress at school. The basis on which retardation was calculated was the number of terms in which individual children had to repeat the same grade of tuition. The details of repetition are important, and will be quoted in full.

These figures need careful analysis to be fully understood. The authors of the report, rightly of course, stress the great benefit received from the regular lipreading training by the majority of the children.

It is important, however, to notice what this really means : through training in lipreading most—not all—of the children with defects of hearing were prevented from becoming more backward than they were when first tested : it does not follow that they were able to recover lost ground or eventually to reach normal educational standards before leaving school (see p. 82).

There is a further point for consideration. We refer once more to the first set of figures " before lipreading." We find that 295 children (i.e. between 6 and 7 per cent.) had repeated grades for more than three terms and 265 (approximately 6 per cent.) for three terms. A significant minority therefore, approximately 12 per cent., of all the children with impaired hearing were one year or more retarded in school progress. Of these a percentage, which cannot be deduced with certainty from the available statistics, continued to become still further retarded in spite of lipreading instruction.

SCHEDULE A.

Number of Grades Repeated Before Lipreading Instruction, 3961.

	Number of Children Repeating Grades.	Number of Grades Repeated.
1 Term . .	858	858
2 Terms . .	499	998
3 Terms . .	265	795
4 Terms . .	165	660
5 Terms . .	130	650
Totals . .	1917	3961

Number of Grades Repeated After Lipreading Instruction, 295.

	Number of Children Repeating Grades.	Number of Grades Repeated.
1 Term . .	247	247
2 Terms . .	21	42
3 Terms . .	2	6
Totals . .	270	295

These observations are made by the present writers in no spirit of criticism—clearly the New York investigation was the most thorough of its type as yet reported. They urge most strongly that in dealing with the child who has defective hearing but would not ordinarily be classified as deaf, further advance lies along two lines. First, there is a need for clinical tests of general intelligence and of positive educational attainment to supplement the results of tests of hearing. Pupils with good intelligence, condemned, through defective hearing, to work with pupils much younger than themselves, or to remain at or near the bottom of the class, have been found to suffer grave injury in social outlook and morale, as well as from educational backwardness and waste of time.

Secondly, these words should be quoted from the New York report : "Just how much more energy and mental strain are consumed by the hard-of-hearing child who is not retarded in order to keep pace with his normal hearing class-mates, or how much more advanced he would be if he were not handicapped with defective hearing, is problematical."

The problem of the mental strain imposed by deafness,

whether in school children or in adults, brings us face to face with factors not purely auditory. How far does deafness of varying degrees of severity limit, not merely the patient's sensitivity to speech as a form of sound, but his power to perceive and understand what is said? The answer to this question will show in what conditions mental strain occurs and how great its extent may be. How far can proficiency in lipreading alleviate strain by increasing the intelligibility of speech to the deaf patient?

Hearing-aids are not mentioned in the New York report. Can lipreading then give enough help to the hard-of-hearing or to more severely deaf patients? Alternatively may not the use of hearing-aids, wherever practicable, together with skill in lipreading, lead to the fullest possible degree of alleviation?

Group-aids give the most efficient form of mechanical help in the classroom. When they are to be used children with defective hearing must be collected together into special classes or special schools. Is this prejudicial or favourable to school progress and the attainment of normal mental standards and outlook?

Parents and the responsible authorities are reluctant to send any child to a special school who can make progress in an ordinary one. Admittedly there are definite dangers and disadvantages inherent in the segregation of those who suffer from any form of defect. It is not necessarily the best way to prepare children for the competitive conditions of adult life.

It may well be, however, that the possibilities of special schools for children with defects of hearing have not yet been fully understood or explored. The historical fact that the earliest of these schools were established for the "deaf and dumb," i.e. children born severely deaf, may have tended to prevent a full realisation of the needs and capacities of boys and girls with less severe deafness.

Until investigation of these matters has been carried much farther it is clear that no child with defective hearing should either be admitted to a special school, or retained in a normal school, without examination of his school progress and tests of his intelligence. In many cases degree of deafness alone cannot be the final criterion.

It is shown elsewhere in this book that investigation has already been carried far enough to make possible at least

provisional answers to some of these questions. The amount of help obtainable from lipreading has been tested in an exact way, so also has the efficiency of different kinds of hearing-aids. In addition, we have used tests of educational attainment to measure (*a*) backwardness due to deafness, and (*b*) the progress of deaf pupils when taught by the hearing-lipreading method.

CHAPTER VII.

THE DETECTION OF DEAFNESS IN THE PRE-SCHOOL CHILD.

This book as a whole is the strongest plea which the writers can make for the earliest possible detection and alleviation through education of deafness in children.

When a bulb is planted for indoor growth, it is put in the dark to grow roots. The early period of growth, of which there is so little outward sign, determines the quality and perfection of the flowers which eventually bloom. If it is not a healthy bulb healthy roots are not grown, but this is not known until later, when shoots declare their own weakness.

This illustrates the mental growth of a very young deaf child. The effects of deafness are at work almost as soon as a deaf child is born. They do not prohibit but they affect mental development very seriously in ways that are not obvious at first glance.

The physical development of such a child may seem, but cannot be, quite normal. For instance, control of the organs of speech and of the particular muscles responsible for the breath-supply during speech, are not being exercised normally in a dumb child. His physique and outward behaviour usually appear normal to parents, who are always ready to note signs of progress. Naturally they are not inclined to look for the subtle symptoms of retardation which would be discernible to an expert eye.

Parents look upon walking and talking as activities in a child which give unassailable proof of his development: they are far more accurate in their judgment about his walking than about his talking. He can or cannot walk by himself. A day comes when he achieves the act alone, a visible definite act for all to see. His progress in talking is much less easy to assess. He may make babbling sounds which resemble words. "Mamamma" and "Daddada" mislead many parents into

thinking that a baby has begun to talk. In any case they are apt to hear, in the sounds he makes, semblances of words.

Deafness in infancy and early childhood can now be detected with greater accuracy than in the past, because so much more knowledge about deafness and valuable statistics about the behaviour of children are available.

It is useful to know, for example, that it is more probable that a deaf child has some capacity to hear than that he has none [1]; that an island or a limited range of hearing may be for high notes or for low notes, or for both high and low notes at certain intensities; that hearing for some parts of words is compatible with total deafness for other parts of the same words.

This knowledge is of great service in the detection of deafness, because it explains many of the inconsistencies which are often puzzling in a young child's behaviour and in his response or lack of response to sounds. Buehler and Hertzer record that from two months onwards an infant normally responds to a noise by turning the head in the direction of the sound.[2] Absence of any form of reaction to loud sharp noises almost always points to total deafness in a child, but his behaviour in response to a more continuous type of sound such as the repeated banging of a door or the clatter of a heavy falling object is different, because a totally deaf child would certainly blink or possibly jump in response to the vibration, though he would not hear the sound.

The writer has observed on more than one occasion a baby, six months old, who later proved to be deaf, turn her head when some one walked across the uncarpeted, boarded floor behind her. The baby also turned her head when hands were clapped behind it; but when a cardboard screen was used to prevent her feeling the wafting air set in motion by the clapping of the hands, there was no response.

Two facts should be taken into account when tests are made of a child's response to sound:

(1) His awareness of vibration through the sense of touch.
(2) His probable capacity to hear some sounds and not others.

[1] Ewing, A. W. G., Ewing, I. R., and Littler, T. S., "The Use of Hearing Aids."

[2] Buehler, C., and Hertzer, H., 1935, *Testing Children's Development from Birth to School Age*, p. 99. George Allen & Unwin Ltd.

From about the ninth month onwards the babbling of a normal child begins to change its nature and to show traces of the influence of hearing for speech. Shorter groups of sounds resembling nonsense words become common and finally definite approximations to words appear. Dawson and Conn's figures show that the average age at which this occurs is about the fourteenth or fifteenth month.[1] During the same period the babbling of a totally deaf child undergoes little or no change. It does not begin to resemble speech proper. From about the eighteenth month it may begin to fall away from normal or to cease.

At this stage also the babbling of a child who has a limited capacity to hear often tends to become somewhat less varied in tone and to reflect more and more only those voice tones which he can hear. It is natural and spontaneous babbling, and its limited range of pitch is not very noticeable.

Valuable as such vocal exercise is to a child's speech development, it is often misleading to the parent.

As a rule people speak to a baby at very close quarters, rarely at a distance of more than 3 feet. A child who can hear even a little therefore has a good chance of hearing the sound of voice to his maximum capacity during babyhood. As soon as he is able to walk and run about independently from place to place, conditions of hearing voice or speech become much more difficult because people often speak to him from a distance.

Between the ages of two and three the effects of total or severe deafness are usually to be seen in a child's behaviour in four ways. He does not pay attention to or respond to speech normally. He does not talk at all or his speech development is very retarded. He begins to use his hands more and more to make his wants known. He often appears to be unreasonably passionate and demonstrative. Inattention to speech is frequently misinterpreted as disobedience or accounted for by parents as indicating extraordinary powers of concentration. The child is said to be too much interested in what he is doing to listen. That may occur with all children sometimes, but it is not normal for a young child to ignore habitually what people say to him. Lack of speech or retarded

[1] Dawson, Shepherd, and Conn, J. C. M., 1931, "Intelligence and Disease," p. 49, *Medical Research Council Report.*

speech are often explained away as being a feature of shyness or even of laziness.

In passing, may the writers say that they have never yet met a child in whom retarded speech development has been due to laziness. They have always found a mental or a physical cause which has accounted for the condition.

The use of gesture by a young child is very attractive and often amusing to adults. The gestures in themselves are performed daintily and skilfully. They show intelligence and also persistence when they are repeated. A child's gestures often appear to the adult as a form of play, rather like that of a puppy which wins attention and response by laying an old slipper at one's feet, as a plea that it may be thrown for him to fetch.

The continuous invention and use of gesture by a child after the age for talking to begin is a warning to parents that his mental development is not following along normal lines.

The occasions when passionate outbursts occur should be observed. Almost always they can be traced to a child's inability to understand what others are trying to tell him, or to make his thoughts understood. To a close and impartial observer there are, as a rule, many signs in the behaviour of a young deaf child which show that his development is, as it were, lopsided.

The lopsidedness may be displayed in different ways. Sometimes by a strong tendency to withdraw from other people and to show resentment actively if they approach him, or by an inclination to sit and do nothing or to play exclusively alone ; sometimes by behaviour which has been described as "bird-witted." The child flits incessantly from person to person and from thing to thing. Nothing holds his attention for more than a moment.

Many young normal children display the same tendencies, but they learn to control, modify and direct them with the help of the closer social contacts made possible by speech.

The physical behaviour of a deaf child may also betray his defect. He may drag his feet in walking. This habit seems to be characteristic of children who cannot hear their own footsteps by bone conduction.

A deaf child's balancing capacity is often defective, owing to disease or to destruction of the labyrinth. His breath capa-

city and control are often poor because they have not been developed in speech.

For the detection and assessment of deafness three aspects of behaviour should be observed :

(1) A child's social behaviour as a whole but particularly his way of making his wants known.
(2) His physical behaviour in the directions already noted.
(3) His response or lack of response to speech and to sounds of different pitch at different distances.

It may be of interest to the reader to follow the details given below in unselected records of pre-school patients who have been brought to the writers for advice about education.

W.

Age.—2 years 3 months.

Behaviour.—Walks well with good balance. Handles play material very intelligently.

Reaction to Sound.—(i) Toy tests : hears drum, whistle, high-pitched and low-pitched bell at 5 feet.

(ii) Speech tests : hears mf. voice at 3 feet.

Speech.—No intelligible speech. Uses clear normal voice persistently. Uses gesture and tries to say a few words to make wants known.

General Remarks.—A friendly, fearless child.

C.

Age.—2½ years.

Family History.—No deafness.

Behaviour.—Drags feet, moves slowly and clumsily. Holds toys loosely and drops them often—not interested in them.

Reaction to Sound.—(i) Toy tests : responded to drum only.

(ii) Voice tests : no response.

General Remarks.—Mother reports that he babbled when a baby but does not babble now. Shy and withdrawing. Was content to sit still and do nothing.

J.

Age.—3 years.

Family History.—No deafness.

Behaviour.—Drags feet when walking. Uses gesture a lot. Plays intelligently with toys.

Reaction to Sound.—(i) Toy tests: could hear high-pitched and low-pitched bell and drum within 3 feet and whistle at 6 feet.

(ii) Voice tests: could hear mf. voice at 2 feet.

Speech.—No words, but babbled in natural tones freely.

General Remarks.—Appeared intelligent but impatient. Mother reported that the child has violent outbursts of temper.

G.

Age.—3 years.

Family History.—No deafness.

Behaviour.—Movements jerky, walks heavily. Makes wants known by crying and gesture.

Reaction to Sound.—(i) Toy tests: no response.

(ii) Speech tests: no response.

Speech.—None. Mother reports that this child babbled until he was about 2 years old; that he is silent now except when he cries and laughs.

General Remarks.—Had great difficulty at first in gaining child's attention. He was unwilling to leave his mother. Later he became interested in toys and eventually learnt very quickly what was wanted of him.

R.

Age.—3½ years.

Family History.—Grandmother became deaf at age of 20. Two sisters are normal.

Behaviour.—Drags feet when walking. Uses the hands a lot to point to things. Appears normal in other respects.

Reaction to Sound.—(i) Toy tests: bells and drum heard at 2 feet.

(ii) Speech tests: ff. voice heard at 2 feet.

Speech.—None, but uses voice in babbling. Laughs aloud normally.

General Remarks.—Independent, bright child. Mother reports—habits clean, helpful with younger sister but will not go near other children. Outbursts of temper sometimes.

A.

Age.—$3\frac{1}{2}$ years.

Family History.—No deafness.

Behaviour.—Walked at 18 months. Shows retardation in handling play material. Interest seldom aroused. Passes quickly from object to object without showing much interest in anything.

Reaction to Sound.—(i) Toy tests : no response.

(ii) Voice tests : no response.

Speech.—None. Mother reports that he babbled when a baby but that babbling ceased after 15 months of age. Sometimes uses voice spontaneously in play. Laughs naturally. Makes wants known by pulling parents' hands.

The information given in the foregoing records was obtained at the first visit. This is not always possible with very young children. It is often more satisfactory to lead up gradually to the toy and speech tests by arranging for several consecutive daily visits. This practice affords the observer better opportunities of watching the child's behaviour in conditions which are familiar to him and also to observe more closely his habits and interests.

Dawson and Conn discuss the relationship between intelligence and the age of walking and talking in children. Their statistics show clearly that the time for talking varies considerably among both boys and girls, but that "the average intelligence decreases as the age increases at which walking and talking begin, and the decrease is slightly greater in the late talking." [1] Retarded speech in early childhood may be due therefore to deafness or to a factor relating to intelligence but not necessarily to lack of intelligence. The essential is to discover the cause of the retardation and for this, tests of hearing are necessary.

It has not been found possible to make pure-tone tests of the hearing of very young children except occasionally after a period of training. Their lack of interest and inexperience in listening to meaningless sounds, such as pure tones, make this form of test unsuitable.

A series of tests with toys and objects has been devised in which the child learns in play to respond to sounds.

[1] Dawson, Shepherd, and Conn, J. C. M., 1931, "Intelligence and Disease," p. 50.

Toy Tests :

(i) Child plays with toy animal, which is made to jump over a fence in response to a movement signal given to the child by the observer. When the child reacts satisfactorily a sound signal is substituted for the movement signal, e.g. the tap of a drum or the clang of a bell, or the sound of a whistle.

The test is repeated but the sound signals are made from behind the child's head and the order of the sounds is changed.

(ii) A game is played. Its object is to identify toys by the sounds they make.

For this a drum, a low-pitched bell, a high-pitched bell, a rattle and a trumpet are used.

Before the game begins the child is encouraged to play with the toys and to sound them again and again.

They are then placed on a table ; child stands with his back to them ; one of the toys is sounded behind his back and quickly replaced among the other toys. Child turns round and identifies the toy sounded.

If he fail to respond to either of the toy tests, they are adapted for him, and he is given the satisfaction of achievement by responding to movement signals instead of to sound signals.

Speech Tests :

(i) This test is similar to Toy Test (i), but voice is substituted for mechanical sounds.

The sound BAH is uttered behind the child's head. When he hears the sound, a toy lamb is made to jump over a fence. The maximum distance at which the child can respond to the sound BAH is noted.

(ii) Toy Test (ii) is repeated but with toy animals.

Certain vowels (AH, OW, EE, OO) are substituted for mechanical sounds. The vowels are associated with the animals thus :

BAH	for	lamb
OW	,,	bow-wow
EE	,,	sheep
OO	,,	moo—cow

(iii) Hearing for consonants is tested in play with trains (SH, SH, SH), a watch (TIK, TIK, TIK), blowing games (P, P, P, F, F, F, WH, WH).

In the last test care must be taken, when it is necessary, to speak close to the child's ears to ensure that his response is given to the sound and not to the flow of breath which he might feel.

The tests described above have been proved to give reliable though non-quantitative evidence of the degree of deafness. They act as a guide to the type of ear training which will stimulate speech in the individual pre-school child.

Below is given a sample test form which is used for young children and upon which observations and results of tests of hearing are entered.

THE DETECTION OF HEARING IN A YOUNG CHILD.
SAMPLE TEST FORM.

Name.............................. Age..........
Family History..................................
Medical History.................................

I. *Behaviour :* [1]
  (i) Walking...................................
  (ii) Handling of Play Material....................
  (iii) Ways of Making Wants Known.................

II. *Reaction to Sound :*
  (*a*) Toy Tests :
    (i) ....
    (ii) ....
  (*b*) Speech Tests :
    (i) ....
    (ii) ....
    (iii) ....

III. *Speech and Babbling :*..............................
....

IV. *General Remarks :*................................
....
....
....

[1] Compare Burt, 1935, *The Sub-Normal Mind.*

Between the ages of 2 and 3 years much can be done informally in the home in preparation for the special form of teaching which is essential for a deaf or severely deaf child from the age of three.

The word " teaching " has been deliberately used, because while the process of learning is identical for all, the conditions under which deaf and normal children learn are different. With the latter, the teacher's skill is used in providing suitable opportunities for a child to learn through play activities which interest him, and which are associated with speech.

A deaf child also learns through play activities how to handle concrete material and practical situations, but without the help of a teacher he cannot associate his experiences with articulate words. Parents have neither the experience nor the knowledge to build the bridge which must connect a deaf child's interests and activities with speech. The most they can do is to prepare the building material and then hand over the construction of the bridge to an expert.

It is shown in Chapters XII and XIII that the approach to speech in a young deaf child is made through lipreading and babbling.[1] There is an excellent leaflet [2] which offers many useful suggestions to parents of deaf children about their upbringing during the pre-school period.

Gesell [3] records the proportion of time in a day spent in vocalisation by a normal baby. At two months 40 minutes a day was spent in vocalisation. At six months 3 per cent. and at nine months 6·66 per cent. of the child's hours awake were spent in some form of vocalisation.

Gesell's figures point to the importance and value of babbling as a preparation for speech. During the pre-school period the young deaf child should be encouraged to babble in the home as much as possible ; to the beating of a toy drum ; to different rhythmic movements ; to the feeling of vibration of a piano (for this he can stand on a chair and feel the front of the piano while he watches the notes being played) ; to the clapping of hands.

All pleasant sounds of voice made by the child should win

[1] See alsoEw ing, I. R., 1931, *Lipreading*. Manchester University Press.

[2] Martin, Margaret, 1931, *What the Mother of a Young Deaf Child Can Do*, Hill & Ainsworth.

[3] Gesell, A., 1930, *Mental Growth of the Pre-School Child.*

approval. Ugly or loud strained tones of voice should be discouraged.

When people babble, sing or speak close to and directly into the child's ear he is enabled to hear to his maximum extent with the unaided ear. This means that parents can stimulate speech in all but the most severely deaf children by natural means. The extent to which such stimulation will promote speech depends of course upon the degree and quality of the individual child's capacity to hear.

The ideal plan is for all who come in contact with a pre-school severely deaf child to make a practice of offering him words in two ways. First a word should be spoken clearly so that he can lipread it and then it should be spoken naturally into his ear and he should be encouraged to repeat what he hears. Mother and child " sing " and " talk " in turn into each other's ears.

CHAPTER VIII.

DISTORTION AND LOUDNESS: NORMAL HEARING FOR SPEECH AND OTHER SOUNDS.

NORMAL hearing for speech is best analysed under the two heads of (*a*) audibility, and (*b*) intelligibility. In the present chapter attention will be concentrated on the question of audibility only.

Every one has realised that speech may be audible without being intelligible. The hum of voices in a distant room of a quiet house is a good example. For those who suffer from deafness ordinary conversation often sounds as indistinct as that, and in certain extreme instances of high-tone deafness patients can distinguish no difference between the ring of a bell and the tap of a drum, even though both can quite definitely be heard. Modern methods of measuring hearing provide an explanation of such experiences and a basis for alleviation.

The results of tests with a pure-tone audiometer, as well as being of diagnostic value, are a reliable basis for estimating the loudness of speech and other sounds to a deaf patient. They indicate also to what extent speech is intelligible and distinct to him in various conditions which he will meet in daily life, when listening with, and without an aid. For, as shown in Chapter II, there are always two factors present making for imperfect hearing—the deficiencies which occur in the best of aids and the patient's own defects of hearing. There is always an element of distortion.

The methods we use [1] to compare hearing for pure tones with hearing for speech are founded upon actual experiments which have been made with normal and deaf listeners.

[1] Ewing, A. W. G., Ewing, I. R., and Littler, T. S., 1936, "The Use of Hearing Aids," *Medical Research Council Report*. H.M. Stationery Office.

Pure-tone tests, first of all, were given to all the listeners. Next measurements were made of the level of intensity at which the loudest sounds in speech were just audible to each listener, whether normal or deaf. This was done as follows. The subject or patient sat inside a sound-proof room. He listened through apparatus, capable of reproducing speech with a very high degree of accuracy, to a speaker or caller in another sound-protected room.

The apparatus was fitted with a large attenuator system, i.e. volume control, made to read in decibels, like the corresponding control on the pure-tone audiometer. The caller repeated again and again the syllable " bah " for as long as was needed to make any one test. By pressing a switch which controlled a lamp in front of the caller the listener signalled each time he heard any sound of the latter's voice.

The caller throughout the tests was careful to speak at a uniform level of loudness and maintained a fixed position at exactly the same distance from the microphone. He had as a guide an instrument, an output meter, connected to the main apparatus. This instrument showed the voltage generated by the loudest sound of his voice as he uttered the syllable " bah." The vowel " ah " was chosen for the test because it is one of the two loudest sounds in English. The caller varied the loudness of the sound as heard by the *listener* by adjusting the attenuator or volume control. In finding the level of loudness at which his voice was just audible he observed the precautions as to timing and repetition which have already been described in connection with pure-tone tests (Chap. VI, p. 68). The level thus determined was called the particular listener's threshold of audibility for speech.

Variations in the threshold of audibility for speech of individual normal listeners were found to be small, usually not greater than 5 decibels. Change of callers caused no wider variation, provided that they maintained the uniform level of loudness as shown on the output meter. Subject to this condition no significant differences were observed between the results obtained with male and female voices.

The pitch of the loudest components in the vowel " ah " is from 700 to 1500 vibrations per second [1] (approximately

[1] See Chapter V, and Fletcher, Harvey, *Speech and Hearing*, p. 272. Macmillan & Co. Ltd.

at C^3). Listeners with normal hearing therefore hear these components of the vowel and these only when its loudness is reduced to the level at which it is only just audible. Normally, then, the threshold of hearing for speech is identical with the threshold of hearing for pure tones of frequency from 700 to 1500 vibrations per second.

When the tests were made with deaf listeners it became clear that the same conclusion did not always apply. Their threshold of hearing for speech was usually found to be at the level of pitch where their hearing for pure-tones was least affected by deafness, within the much wider pitch range of 250 to 4000 vibrations per second.

A deaf patient, therefore, sometimes hears the weakest components, in a vowel or consonant or in a musical tone, better than the loudest components. This means that he hears speech and music in a very distorted form.[1]

The nature of the distortion has during many years been demonstrated at Manchester University by means of gramophone records. Sound filters are used which have the same kind of effect as the deafness of certain patients and which filter out or reduce the loudness of sound over particular ranges of pitch.

Marked deafness to upper tones coupled with much better hearing for lower tones is shown to have a dulling or " flattening out " effect. In speech it makes consonants indistinct and in extreme cases it even destroys the differences between vowels, which are all then reduced to what is approximately one form of noise.

Severe deafness to lower tones, on the contrary, when combined with considerably less severe deafness to upper tones makes speech, as heard by the listener, weak in volume, thin and reedy. It remains distinct, however, so long as it can be heard at all.

We shall see later that these facts are important when it comes to measuring the effect of deafness on the intelligibility of speech.

Such distortion often greatly alters the quality of musical sounds as heard by deaf listeners. It can be demonstrated with a gramophone record of a violin and piano duet. If the record is played on a good electrical reproducer fitted with

[1] See Acoustic Spectra, Chapter V.

suitable sound filters three renderings may be made available, as heard by

(*a*) the normal listener, when no sound filter is used ;
(*b*) the high-note deaf patient, when the low-pass system is employed ; and
(*c*) the low-note deaf patient, when the high-pass filter system is connected.

In the version to which the high-note deaf patient is accustomed the piano quality is most prominent. The violin is much fainter and markedly flattened in quality. Because of the loss of important overtones it sounds much like a flute. In the opposite version, as heard by the low-note deaf patient it is the piano which is most affected. Whole bars played on it may become faint or inaudible while the violin retains most of its natural quality.

Analogous effects may be demonstrated with records of noises. For instance, the chimes of Big Ben are perceptibly but not strikingly affected by high-tone deafness, but the noise of a telephone bell may be completely suppressed.

The reader will have understood that distortion always results in a diminution of the total volume of sound heard. The greater the distortion the smaller is the proportion of the sound which remains unsuppressed.

There is plenty of evidence that patients often become habituated to hearing all kinds of sounds so distorted. There is always the risk that when choosing a hearing-aid they may, if left without adequate skilled advice, select an aid because it gives them the same incomplete and distorted balance of sound to which they have grown accustomed, although an aid which would have the effect of correcting the imperfection and distortion would actually make speech more intelligible.

A further effect of the distortion of sound by deafness is on the patient's own speech. When the condition has existed from birth only skilled training by an experienced teacher can help a child to talk normally. Otherwise he speaks as he hears, because he has never heard any other, i.e. a perfect version of speech. Older patients often need the same skilled assistance to prevent speech deterioration. Without it they, too, in time, cease to have a normal standard.[1]

[1] Fletcher, Harvey, *Speech and Hearing*, p. 26.

The measurement of noise.

Tables of the loudness or intensity of common sounds have been calculated by physicists as the result of exact measurement. The method, described above, of finding the level of loudness at which a sound is just audible to a listener needs a sound-proof room, and cannot therefore be used in the street, or, very easily, in the factory. Another method is that of harmonic analysis, i.e. to record the sound by photographing it on a moving film and then to analyse the frequency and intensity of its components. The acoustic spectra illustrated in this chapter and in Chapter V were obtained in this way. This method is wholly objective and mechanical, which is on the whole an advantage since normal listeners vary, but the apparatus is exceedingly complicated and not portable.

For measuring the loudness of all sorts of noises in all sorts of places the portable apparatus known as a noise-meter is now held to be exact and is easily manageable. The essential characteristics of the noise-meter of National Physical Laboratory type were described by Dr. G. W. C. Kaye in his important presidential address to Section A (Mathematical and Physical Sciences) of the British Association, at its annual meeting at Nottingham in 1937.[1]

A noise-meter, of the objective type which records loudness on a dial and needs no human listener, has " a pressure microphone connected to an amplifier provided with calibrated control." [2] An output indicator is attached, and sound falling on the microphone, provided that its loudness exceeds a certain minimum value, is registered on the instrument. The chief purpose of a noise-meter, however, is to measure the loudness of sound as it appears to a human listener.

Now the sensitivity of the human ear is greatest for sound of middle frequencies (see p. 58). A noise-meter has therefore to be made ear-like. Sound-filter systems are incorporated to make it less sensitive to sounds of lower and higher pitch. Without these filter systems the instrument would record the actual intensity of sounds but not their effect on the normal human ear.

[1] Kaye, G. W. C., " Noise and the Nation," *Nature,* 140, pp. 446-9 and 490-1.

[2] Compare calibrated control of audiometer, p. 65 above.

Kaye reports also that the inertia of the instrument has to be of the right order " to stimulate the salient characteristics of the ear in dealing with either steady or impulsive sounds. For example, the ear does not record full strength until a steady sound has persisted for about one-fifth of a second."

British workers who use a noise-meter express the measurements which they make with it in terms of a unit called the phon. For measurements of intensity values or energy levels they use the decibel scale as described in a preceding chapter. They prefer not to use the same term to describe loudness levels as they appear to the ear.[1]

The difference between these two sets of values may be understood from the example, which has already been mentioned, but which may perhaps be quoted again, of certain low notes produced by an organ. Because of the relative insensitivity of the ear to sounds of low pitch very large energy and intensity levels must be reached to create an impression of loudness on the human listener. The intensity of a sound may therefore be relatively large as measured in decibels but small as measured in phons.

In the design of noise-meters a standard unit had to be agreed upon as the basis of a measurement. A pure reference tone was therefore selected which has a frequency of 1000 vibrations per second. As the zero of loudness a pressure of 0·0002 dyne per sq. cm. was adopted. This, in the case of sound of 1000 vibrations per second, is at or near the normal threshold of hearing.

In what way, however, could the loudness of sounds of frequency higher or lower than the reference tone, or the loudness of complex sounds, be measured and compared? To obtain the necessary standards, tests of human listeners were needed. The intensity of the reference tone was adjusted by decibel steps until its apparent loudness matched, in their opinion, the apparent loudness of the noise or sound which it was required to measure. The results of these tests provided a basis for the design of the sound-filter systems which make the noise-meter respond like the average of any number of human listeners.

[1] American physicists have used the words " loudness " or " loudness level " to express the results of many experiments of basic importance in this field of work. See Fletcher, Harvey, *Speech and Hearing*, pp. 225-44.

Before ear-like noise-meters were constructed various earlier means of measuring noise were in use, in addition to those that have been already mentioned. Bell Telephone Laboratories made tests on a "deafening effect" method.[1] A listener's hearing was tested in the presence of a noise and the results compared with the values for the threshold of hearing in a sound-proof room.

There was also the "balancing method"[2] by which an artificial noise was created and its loudness adjusted or graduated until the observer considered that its loudness was equal to that of the sound to be measured.

The gramophone[3] audiometer is stated by Fletcher to be very useful for this purpose "if records are available which have a character of noise similar to the type which it is desired to measure."

These three methods are subjective, dependent upon personal judgment. Therefore unless a team of listeners is to be employed for every experiment there is a risk of personal bias. Also they often involve technical difficulties. Kaye, in the paper to the British Association already quoted, has said: "There can be little doubt that the future of sound or noise measurement, from a practical point of view, lies with the objective meter. . . . It is free from personal bias, rapid in action and direct reading, and can be put into the hands of an untrained observer."

Loudness levels of speech and common sounds.

The following table, given by Kaye, is of great help in assessing the effects of deafness on ability to hear speech and common noises.

A patient whose deafness, as measured by a pure-tone audiometer, is 60 decibels at the frequency of 1000 vibrations per second and not less over the rest of the range of pitch involved in speech (90 to 8000 vibrations per second), can neither hear nor understand quiet conversation, the loudness level of which is 60 phons, except by lipreading.

Noise at loudness levels below 60 phons, e.g. the tearing of paper at 3 feet, is inaudible to him. He is able, however, to hear and understand something of loud conversation, especially

[1] Fletcher, Harvey, *Speech and Hearing*, pp. 104-5.
[2] Ibid., p. 105. [3] Ibid., p. 105.

if the subject and wording are very familiar. He can probably enjoy loud music, whose intensity is 80 phons,[1] and unless he suffers from old-age or some other extreme form of nerve deafness, he will hear speech most distinctly when its loudness corresponds to the level of 90 to 110 phons. Without a hearing-aid, these levels can only be reached when speech is uttered in an ff. voice 8 inches or less from the ear.[2]

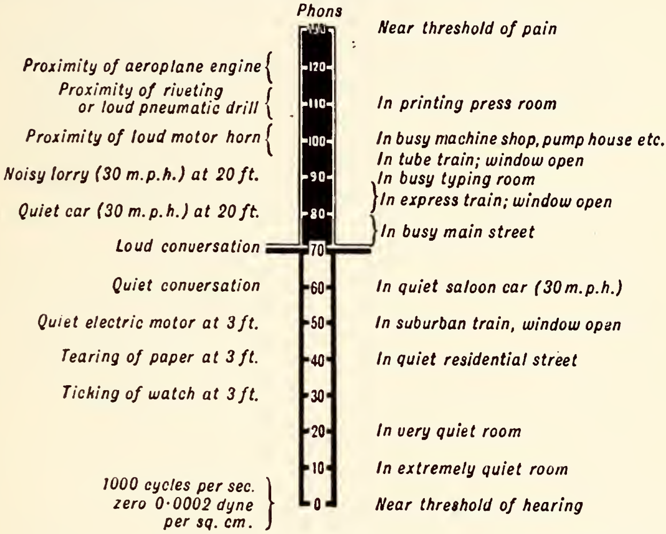


DIAGRAM 23.—Approximate loudness levels of common noises.

Such a table is essential if the effects of deafness on the audibility of sound to the unaided ear are to be understood. It also makes an initial basis for estimates of the extent to which amplification by a hearing-aid will enable the deaf patient to hear sound otherwise inaudible or unintelligible. For instance, a sound, reaching the microphone at an intensity of 60 decibels above the normal threshold of audibility, if amplified 30 decibels by an aid, has an intensity of 90 decibels when it arrives at the listener's ear.

The writers feel obliged, however, as the result of experience, to warn readers very emphatically that the effects of deafness on the audibility of speech cannot be finally and accurately estimated without reference to additional factors. The intensity

[1] Davis, A. H., 1934, *Modern Acoustics*, p. 271. G. Bell & Sons, Ltd.
[2] Fletcher, Harvey, *Speech and Hearing*, pp. 202-6.

of quiet conversation, when examined in detail, varies over a very wide range, by as much as 56 decibels.

The chief factors responsible for this, apart from distance, are :

(*a*) differences in the intensity of particular vowels and consonants ;

(*b*) differences due to the use of accent, stress or emphasis, e.g. in word " to-morrow," where the second syllable is given more power than the first and third, and in a phrase, " He actually *walked* home " ;

(*c*) differences in the strength and quality of individual voices ; and

(*d*) effects of deafness which is greater for one part of the range involved in speech than for other parts.

In addition it should be said that scales of loudness levels hold good only in average conditions where there is no excessive reverberation or reflection from walls and other hard surfaces.

Before going on to discuss the other factors affecting audibility it may be helpful to illustrate further the application of loudness tables to deafness, by a concrete example.

The most serious consideration for any listener is his ability to hear average conversation in an mf. voice.

Let us think of a patient who is 50 decibels deaf, i.e. all of his pure-tone thresholds over the frequency range 256∼ to 4096∼ vibrations per second are 50 decibels above normal. He is considerably less deaf than the patient discussed earlier in this chapter. He hears the loudest sound components in quiet conversation at 60 phons. Without the help of lipreading or an aid, he sometimes makes mistakes, because what he hears is very imperfect. In average conversation at a distance of 3 feet from the ear the loudest vowels rise far above the normal threshold of audibility, yet even then a few of the weakest consonants tend to be indistinct.[1]

Our patient is able, of course, to follow what is said much more easily if the speaker raises his voice or talks quite close to his ear. Better still he can almost invariably follow quiet conversation with the help of a sensitive and accurate hearing-aid together with lipreading. The aid, however, to give the maximum degree of help, needs to be sufficiently powerful

[1] Fletcher, Harvey, *Speech and Hearing*, pp. 272-8.

to amplify sound at 1000 vibrations per second by 30-50 decibels, i.e. to raise its loudness to a level 90-110 decibels above the normal threshold of audibility.

To some small extent deafness is an advantage to this patient in so far as it saves him from mental distraction by noise which is irrelevant to his purposes. The background of noise in an average office (30 phons) [1] will be quite inaudible to him and even a railway train in motion may appear quiet. In a busy street, an express train or in a motor-car, provided that he is not markedly nerve-deaf, he can follow conversation with the unaided ear, because the passengers are obliged to talk very loudly to hear themselves and each other above the general noise, which masks ordinary mf. conversation.

A patient whose relevant thresholds of audibility are higher than 100 decibels above normal cannot ordinarily be reached by the human voice, although a few instances have been recorded in which listeners with such high thresholds (too deaf to hear the noise in a busy machine shop) have been helped to a useful extent by a suitable hearing-aid.

Differences in loudness between particular vowels and consonants.

As previously mentioned, conditions may and do occur in which some but not all vowels and consonants are sufficiently loud to rise above the threshold of audibility. For the deaf patient this may be either when listening with the unaided ear or when using a hearing-aid. It is in fact extremely difficult to help deaf patients to hear the weakest consonants in quiet conversation by means of mechanical aids.

The following table (p. 106) shows the relative loudness levels of 13 vowels and 20 consonants as given by Fletcher. The speakers and listeners taking part in the experiments were American. The method of measurement was that of reducing each sound to the level at which it could no longer be heard. The technique employed was therefore similar to that already described above in connection with the threshold of audibility for speech. In our table Fletcher's figures have been adjusted to give the loudest vowel, " ó " as in " talk," the loudness level of 60 decibels above the normal threshold of audibility. The conditions represented, therefore, approximate to those of quiet conversation. It is demonstrable by experiment that this

[1] Fletcher, Harvey, *Speech and Hearing*, p. 187.

vowel is approximately equal in intensity to "ah," as in "bah," used as the loudest vowel in our tests.

*Loudness Levels of Vowels and Consonants.**

(In decibels above normal threshold of hearing.)

ó	(talk)	60	n	(no)	46·8
o	(ton)	59·6	m	(me)	45·4
ō	(tone)	59·6	th	(that)	44·2
ī	(bite)	59·5	t	(tap)	44·1
ou	(bout)	59·2	h	(hat)	43·9
á	(tap)	59·2	k	(kit)	43·8
e	(ten)	58·4	j	(jot)	43·7
a	(top)	57·4	f	(for)	43·6
u	(took)	57·1	g	(get)	42·9
ū	(trot)	55·9	s	(sit)	42·4
l	(let)	53·5	z	(zip)	41·6
a	(tape)	53·3	v	(vat)	41·4
i	(tip)	52·6	p	(pat)	40·6
ē	(team)	49·4	d	(dot)	38·9
ng	(ring)	48·9	b	(bat)	38·8
sh	(shot)	48·9	th	(thin)	38·7
ch	(chat)	47·2			

With one exception, therefore ("l" as in "let"), all the vowels are louder than any of the consonants.

A classification based on differences in intensity of the order of 10 decibels gives one group of 12 vowels and the consonant "l," with intensity 50-60 decibels, a second group, including the vowel "ēe" and 16 consonants, with intensity from 40-50 decibels, and finally a group of three very weak consonants, "d," "b," and "th" (thin) with intensity 38-40 decibels. In quiet conversation, therefore, vowels are much above the threshold of audibility but the weaker consonants have a considerably smaller margin. Even a listener with normal hearing sometimes finds "v," "f" and "th" difficult to recognise at intensities commonly used in conversation.[1] It will be realised therefore that relatively slight losses of acuity to the extent of 20-30 decibels further diminish the intelligibility of speech. Patients suffering from such degrees of deafness do

* After Fletcher, Harvey, *Speech and Hearing*, p. 73, Table IX.

[1] Ibid., p. 276.

not need hearing-aids but they benefit from the habit of watching the lips of speakers.

Variations in loudness due to emphasis or accent.

Those who suffer from defective hearing often experience great difficulty in catching unstressed or unemphasised words and syllables. Fletcher[1] states that syllabic power (the loudness of a syllable as a whole) " varies more with the emphasis given than with the vowel used. A vowel in an accented syllable has usually three or four times as much phonetic power as one in an unaccented syllable." The significance of this is best understood from an illustration. A speaker talking in an mf. voice says, " This is a very *short* corridor," emphasising the word " short." The intensity or loudness of the vowel " aw " in " short " will then probably be about three or four times greater than that of the same vowel when used in the third and unaccented syllable of the word " corridor." Fletcher adds : " This difference is dependent upon the speaking habits of the individual. . . . Although no measurements have been made upon persons who have been trained to speak distinctly, such as actors and public speakers, it is very probable that such tests would show that the weaker sounds would be given considerably more power by such trained speakers than is ordinarily used by the average speaker. Due to this cause, the range of intensities used by such speakers would be narrower. . . ." The present writers would add that identically the same type of speech—in which unaccented syllables and unemphasised words are given more weight and loudness than by the average ordinary speaker—is best heard by patients suffering from defects of hearing.

Variations in loudness among different voices.

Variations in loudness under this head are very often a source of difficulty to listeners with defective hearing. They say (and sometimes justly) that certain speakers " mumble." Such variations are also of great importance when tests of hearing-aids are made in uncontrolled and non-standardised conditions. The results of tests, made by a speaker with a clear and powerful voice and habits of careful and distinct enunciation, will necessarily be much more satisfactory to the

[1] Fletcher, Harvey, *Speech and Hearing*, pp. 71-6.

patient than those which he will experience with less good speakers. To some extent broadcasting has convinced listeners who have normal hearing that voices vary very greatly in audibility. Differences both in quality and volume between the voices of men and women are often very marked.

Sacia (quoted by Fletcher) [1] says: "I have become able to associate peak factors with vocal qualities in the following way: the voices with the highest peak factors are those which in the ordinary terminology are said to be 'resonant' or 'vibrant'; they have the greater carrying power, especially over the telephone; they are rich in the musical sense and are, therefore, well suited to singing, although many such voices are never applied to the art."

Statistics about variations in the strength of the voices of different individuals are not numerous. Fletcher quotes figures obtained from tests of a number of average American speakers. The extreme range of variation in average speech power was found to be rather more than 20 decibels. Thirty per cent. of the speakers tested talked with less than a quarter of the speech power which was the average for the whole group. It is possible that many persons who for reasons of age, health and occupation would not be employed in making laboratory tests, would speak even more quietly.

Amplification problems.

Taking into account differences between particular vowels and consonants, variations in stressing, and differences between individual voices, Fletcher estimates that the peak value of the loudest sound that will be encountered in conversation is 500,000 times greater than that of the weakest sound. This is a range of 56 decibels. It indicates something of the extent of the problems involved in the design of efficient hearing-aids. Often they are used by patients who are 50 or more decibels deaf to sound of all frequencies. Ideally, these patients should be enabled to hear the weaker consonants in quiet conversation. The intensity of these consonants should be raised as much above the patient's threshold of hearing as it is ordinarily above the normal listener's. At the same time, however, the loudest vowels would be correspondingly amplified, not to

[1] Fletcher, Harvey, *Speech and Hearing*, p. 75.

mention any extraneous noises, such as coughing, that might occur.[1]

The consonant " p " would require to reach a minimum intensity of 90 decibels above the normal threshold of hearing (because the least deaf patient of whom we are now thinking has more than 50 decibels loss, and the average intensity of " p," in quiet conversation, is 40 decibels above the threshold of hearing of the normal listener). Such amplification or magnification would, however, inevitably raise the intensity of " aw " to a level more than 110 decibels above normal threshold (since " aw " usually has an intensity 20 decibels greater than " p," and the speech power of the more powerful speakers is greater than the average). Now in this case an intensity of 110 decibels approximates closely to a loudness of 110 phons. That is the level of noise in the proximity of riveting or of a pneumatic drill. It is also not very far from the threshold of pain. Two practical questions therefore arise :

Can hearing-aids be constructed to produce accurately such loud sounds ? and

If such aids are, or may some day become, technically possible, will a deaf listener be able to endure these loud sounds for any continuous period ?

[1] Unless some form of automatic volume control, effective to an extent at present unknown, were available.

CHAPTER IX.

TESTS OF HEARING-AID EFFICIENCY.

UNTIL a short time ago the complete lack of reliable information about the capacity and efficiency of the various types of hearing-aid available to the public was a great handicap to their prescription on a scientific basis.

The publication by Littler [1] of the results of a series of measurements of hearing-aids, made under working conditions, was therefore an event of great importance to deaf people. These results make it possible to discuss all the various problems relating to the use of aids on the basis of accurate and definite information. In the past hearing-aids have only too often been the subject of theory and hypothesis which had little relation to fact.

The writers have heard it stated, for instance, that a certain kind of aid had the advantage that it did not reproduce the noise of a typewriter. Actual measurements made by Bell Telephone Laboratories [2] show, however, that the masking effect of typewriter noise occurs over a very wide range of pitch and is particularly noticeable from 512 to 4096 vibrations per second. Now this is precisely the most important range of pitch for speech, as has been explained in earlier chapters. An aid, therefore, which suppressed typewriter noise would fail also to reproduce the most important speech sounds.

An instance of a similar kind is the widespread though vaguely held conception that the use of electrical aids in some way involves an element of risk which is not to be met in the case of non-electrical sound-collectors and speaking tubes. Patients, in the past, have sometimes been advised against

[1] Littler, T. S., 1936, "Hearing Aids for the Deaf," *Journal of Scientific Instruments*, 13, 5, p. 144.

[2] Fletcher, Harvey, *Speech and Hearing*, p. 106.

the use of electrical aids on account of some threat to their remaining power to hear, which has not always been clearly specified.

Littler's statistics tell us, in a reliable manner, to what levels of loudness the various kinds of hearing-aid in modern use raise speech and other common sounds of daily life. They show the relative powers of amplification possessed by aids electrical and non-electrical. They reveal clearly the fact that it is through distortion and parasitic noise and not excessive loudness or any effect of listening through a telephone, that some of the most popular types of aid have proved unable to give effective help to many patients—especially to the elderly and the nerve deaf.

The use of hearing-aids is safe.

If I use an aid, will it make my hearing worse? This is often asked by patients, and in the past there has evidently been uncertainty in the minds of some professional workers also.[1] There seem to have been several different reasons, which have now been disproved, for such an attitude. One of the most worthy of consideration was the suggestion that the artificial amplification of sound must throw more work on the ear and the nervous mechanism of hearing as a whole, and that the result might be injurious to patients whose auditory mechanism was in any case defective.

The results of very thorough investigation seem entirely to discredit this theory. Tests have been made of the hearing of a number of deaf patients, who have used hearing-aids of the most powerful kind for some years. The majority of patients show no change. Some, chiefly those deaf from birth, give better results on an acuity test, after regular use of high-quality hearing-aid apparatus combined with lipreading.

Since statements appear from time to time about improvement, rather than loss, of hearing, after prolonged and regular use of an aid, the writers feel that they ought to quote the evidence which they have available.

Diagrams 24, 25 and 26 illustrate changes in the hearing of a patient, as shown by the results of pure-tone testing over a period of five years.

[1] Watkyn-Thomas, F. W., and Lowndes Yates, A., 1932, *The Principles and Practice of Otology*, p. 260.

The age of this patient at the first test was 10 years. She was deaf from birth and had previously been considered totally

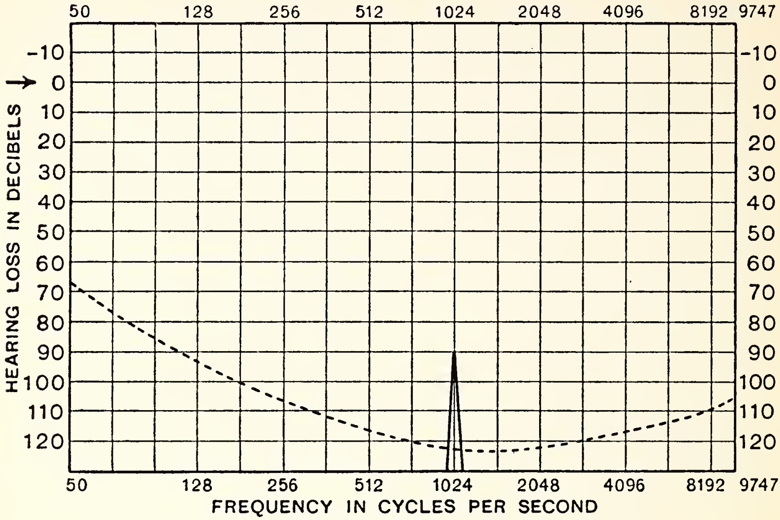


DIAGRAM 24.—Patient N.A. 1. Air conduction.

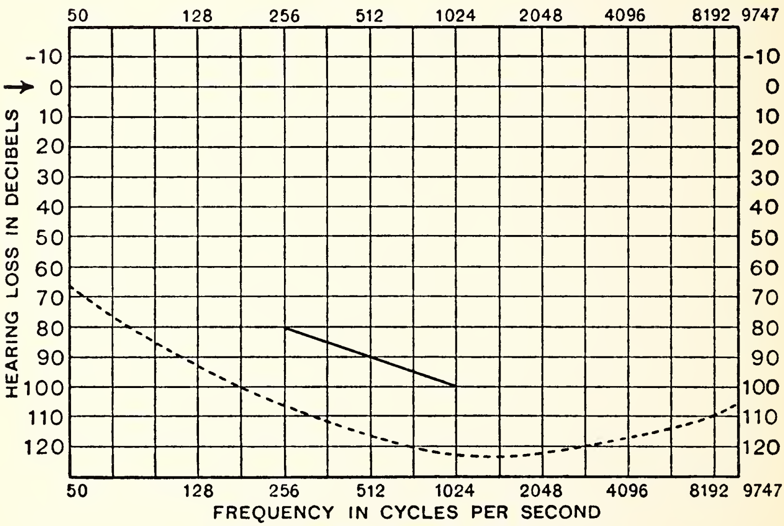


DIAGRAM 25.—Patient N.A. Air conduction.

deaf. She cannot hear the human voice without hearing-aid apparatus unless the lips of the speaker are within a few inches

of her ear and unless the voice is raised to ff. level. Then she can tell when vowels are uttered but cannot distinguish between them. The extent, limited but useful, to which she is helped by means of powerful and accurate hearing-aid apparatus in combination with lipreading is discussed in Chapter XVII, p. 291.

At the first pure-tone test of the right, which is the better ear, she was aware of sound only at 1024 vibrations per second. After lessons in speech and school subjects in which the apparatus was used for nearly two years, she heard sounds of lower pitch also, from 256 to 1024 vibrations per second. Five

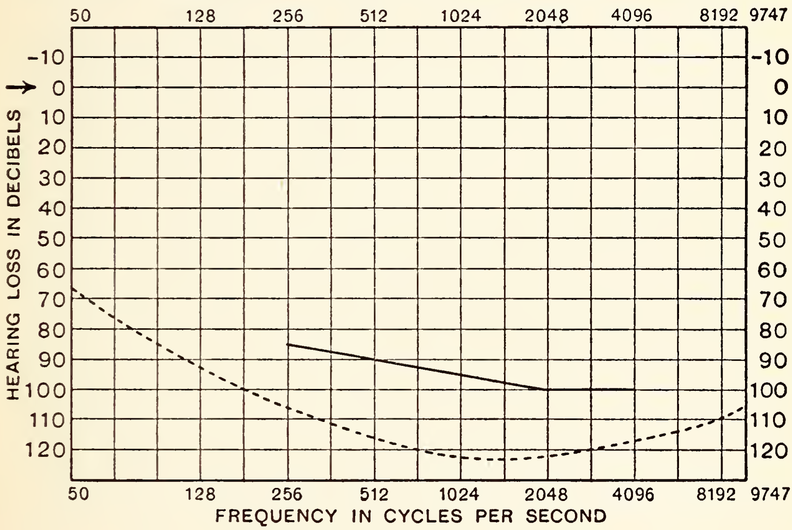


Diagram 26.—Patient N.A. 3. Air conduction.

years after the first test she was responding to still lower frequencies, from 128 to 1024 vibrations per second.

It must be pointed out that her acuity at 1024 vibrations per second, the frequency at which response was first shown, remained virtually unchanged throughout the whole period. It was awareness of sounds of other frequencies that was developed.

Tentatively and on the basis of a number of similar instances, the writers would say that this is a characteristic feature of such apparent improvement in acuity, as shown by the results of pure-tone testing. They believe that it is probably due to

8

the mental factor of increased skill in noticing weak sounds, and to provision, through the hearing-aid, of opportunities for associating the sound of the human voice, however imperfectly heard, with speech, the meaning of which was acquired chiefly through lipreading and reading. Physiologically, it would seem, the auditory mechanism was capable of the same response before the lessons as it was after them. Mentally, the pupil had so rarely heard sound of any kind, at the intensity levels given to speech during the lessons, that she had not developed sufficient interest in it nor associations centring round it, to become a skilled and careful listener.[1]

This view is held also by Knudsen and Jones.[2]

The experimental evidence, then, indicates that the use of hearing-aids, so far from increasing deafness, sometimes leads to greater skill in the detection and recognition of sound. There is always, nevertheless, the patient who has been advised by the aural surgeon that his deafness is progressive. He, unfortunately, is likely to get worse whether he uses an aid or not. There are a small number of instances among our records of such patients, whose capacity to hear has to some extent diminished over a period of years. The evidence which is about to be described, however, points to the conclusion that the best course for these patients also is to enjoy the use of an aid for so long as they can. There is always in each individual case the hope, and so far as can be judged from existing records, a considerable possibility, that their deafness may not become so severe as to prevent them benefiting to a limited extent from a modern valve aid for the rest of their lives.

Conditions of auditory fatigue.

So much importance attaches to the question whether hearing-aids are safe, that it was imperative to find what kind of loud sounds produce an ill-effect on the human ear.[3] It had long been known that animals may be deafened by exposure to very loud sound if it is continuously maintained for many hours or days. When guinea-pigs, which had been so

[1] Compare Ewing, A. W. G., *Aphasia in Children*, pp. 115-18; also Chapter XVII, p. 288, of this book.

[2] Knudsen, V. O., and Jones, J. H., 1935, "Artificial Aids to Hearing," *Laryngoscope*, 45, 1, p. 24.

[3] Ewing, A. W. G., and Littler, T. S., 1935, "Auditory Fatigue and Adaptation," *British Journal of Psychology*, 25, pp. 284-307.

treated, were killed, and when their ears were examined, the nervous mechanism was found by Yoshii to be partly destroyed.[1]

We decided to listen to sound of intensity up to 110 decibels above the threshold of hearing. Apparatus was designed by Littler, which produced pure tones over a range of loudness not available to previous workers on auditory fatigue. The effects of varying the pitch, loudness and duration of the test sounds used was studied.[2]

The experimenters were joined by other subjects with normal hearing. Later, when the effects of the sounds could be predicted, the tests were extended to include deaf patients. The most important conclusion for deaf patients was that very loud speech has not the same effect on the ear as very loud pure tones, or very loud sounds of uniform pitch, such as had been used by those workers who made tests with animals.

Pure tones, if sufficiently loud and sufficiently prolonged, diminish the acuity of hearing of normal listeners. This diminution, during the experiments, was sometimes severe, in a few cases it was equal to as much as 30 decibels loss of hearing, but it was always temporary. The label temporary or experimental deafness has been suggested. Individuals vary in susceptibility to it. It was invariably produced in normal ears by listening to sound of uniform pitch, continuously, for two minutes, at 110 decibels above the normal threshold of audibility. Organic deafness, even when there is an element of nerve deafness, does not increase, so far as has yet been ascertained, but decreases, susceptibility to auditory fatigue. Only one deaf patient has shown auditory fatigue as the result of listening to very loud pure tones, and that only to a slight extent.

No deaf or normal listener, however, who took part in the tests, was found to suffer decrease of hearing after listening to very loud speech. The explanation is most probably to be found in the rapid changes of pitch and loudness which occur in speech. These can be understood from the tables and diagrams given earlier in this book. The duration of the peak or loudest sounds in speech is never greater than half a second.

[1] Yoshii, U., 1909, *Experimentelle Untersuchungen über die Schädigung des Gehörorgans durch Schallenwerkung. Z. Ohrenheilk*, 58, p. 29.

[2] Compare also Rawdon Smith, A. F., "Auditory Fatigue," 1934, *British Journal of Psychology*, 25, p. 1.

In our clinic a very few elderly patients have been reported as unable to benefit from an aid after a few minutes' use, although at first they seemed to be helped. There has been no opportunity as yet to make measurements to find whether this experience in individual instances is physical or psychological. It appears in any case to carry its own preventive, namely, that the patient wishes no longer to persist in using the aid.

As opposed to the theory, already mentioned, that amplified sound may in some way injure the ear by over-stimulation, there is the fear sometimes expressed by patients that because a hearing-aid relieves the (mental) strain of deafness its continued use will leave their ears less responsive to sound when unaided. A patient will say, "I'm afraid of my ears getting lazy." Knudsen and Jones have commented on this supposition with some severity.[1, 2]

They say: "In the popular mind there is an almost universal fallacy. People are afraid to use hearing-aids because they have been told over and over again, 'If you once use a hearing-aid you will never be able to get along without it.' . . . Although the idea is false, it will probably take from twenty-five to fifty years to eradicate this concept."

They go on to point out that it may have arisen from an entirely misleading analogy with spectacles. They say that the use of glasses, which relieve eye-strain, may cause the patient to lose some of his power of accommodation, so that when he takes them off he cannot see so well as he could before he began wearing glasses. "A hearing-aid gives no such result. When an aid is used the sounds are simply made louder. When the aid is taken away the ear hears precisely as it did before the aid was used."[3]

The most recent information about the middle ear shows that it is unlikely that the tympanic muscles ever increase its sensitivity. Apparently they are brought into action to deal with very loud sounds, whose amplitude they diminish. It cannot be said that, in any sense whatever, they focus the ear upon sound. Their function seems rather to be pro-

[1] Knudsen, V. O., and Jones, J. H., 1935, "Artificial Aids to Hearing," *Laryngoscope*, 45, pp. 48-69.

[2] Compare also Watkyn-Thomas, F. W., and Lowdnes Yates, A., *The Principles and Practice of Otology*, p. 260.

[3] Knudsen, V. O., and Jones, J. H., "Artificial Aids to Hearing," p. 48.

tective—possibly to preserve the nervous mechanism of hearing from excessive stimulation.

Spectacles and hearing-aids have, indeed, very little in the way of common features. "Eyeglasses simply refract light waves; that is all that is expected of them," Knudsen and Jones continue in the article already quoted: "If an eye has ulcers of the cornea, opacity of the fluid in the anterior chamber, a cataract of the lens, or opacity of the vitreous—all the eyeglasses in the world could not overcome such conductive defects. . . . In practice no one asks for eyeglasses which will overcome opacities; it is universally known that vision is impossible through an opaque substance."

"Consider similar lesions in the ear," they write: "atresia of the external canal; thickening or stiffening of the drum membrane; arthritis or fibrosis of the ossicular chain; or fixation of the stapes in the oval window—such lesions are analogous to the lesions of the conductive mechanism of the eye. Fortunately, although . . . we cannot transmit light through the conductive lesions of the eye by the amplification of light . . . we actually can transmit sound through the conductive lesions of the ear by amplification of sound."

There is, therefore, always this fundamental difference in the purpose of spectacles and of hearing-aids, namely, that spectacles are used for focussing and hearing-aids for magnifying. To fulfil their function all hearing-aids, except those of weak type, draw upon additional sources of energy, stored up in batteries, or from the electricity mains supply.

For this reason they are helpful, also, to many patients suffering from mixed deafness and cochlear or inner ear trouble. Such patients, as related elsewhere in this book, form a majority amongst those who use aids.

Standardisation of hearing-aids.

Patients sometimes say that they have been advised to go to some commercial firm, or to several firms, and to try all the aids there until they found one to suit them. The results of this "hit or miss" method, or lack of method, are only too often a waste of money. No one would suggest it as the best way to deal with a defect of sight. Yet modern hearing-aids and problems of hearing are more complicated than spectacles. Problems of hearing are exceedingly complex. Acoustic

conditions vary enormously. The best expert advice that can be had is essential.

Hearing-aids need not merely to be tested but also to be standardised. Experience proves that important variations in sensitivity and efficiency are sometimes found amongst different models of the same aid. There is need for a minimum standard of efficiency to which every instrument, according to its type, must conform. In cases of complaint by patients and where no obvious defect, such as a broken valve, is apparent, the aid should be retested to see whether it retains its original efficiency. Otherwise there is the risk that in all good faith the patient may be told that his deafness has increased and that he should now buy a larger and more powerful instrument.

In the past, tests of the efficiency of hearing-aids, such as Littler has reported in the article already quoted, were not perhaps within the reach of all commercial firms. A technique is now available and the equipment is not unduly costly.[1] In the case of component parts for wireless receivers, for public address purposes and for cinemas, etc., the publication of the results of tests of efficiency is often taken for granted. Publication of similar information by manufacturers of hearing-aids could not fail to be to their advantage, by increasing public confidence in the efficiency of their instruments.

Essential characteristics of hearing-aids.

Littler [2] has shown that the two essential characteristics of a hearing-aid are

(1) the amount of parasitic noise which it itself makes ;
(2) its capacity to amplify sound over the range of pitch involved in speech.

Parasitic noise.

This noise is independent of external sound falling on the microphone. It will be heard if the aid is used in the silence of a sound-proof room, and it may increase in severity the longer the aid is kept in continuous use or the older it gets.

Parasitic noise is usually of a "rushing" kind ; "crackling" is generally due to an imperfect connection or a dry battery

[1] Certain firms have begun to quote results of tests of their instruments made at the National Physical Laboratory, Teddington. This seems to be a most desirable practice.

[2] Littler, T. S., "Hearing Aids for the Deaf," p. 144.

that is almost exhausted. Parasitic noise is easily distinguishable from the " howling " sound which occurs when the aid is switched on and the uncovered telephone is brought within a certain distance of the microphone. This " howling " is due to sound reaction and is set up in public address systems if they are made too sensitive. It resembles a whistle or the sound of a musical instrument.

The intensity of parasitic noise can be measured, as will be shown shortly. If a deaf patient cannot hear it, its existence is usually of no consequence to him. If, on the contrary, it is audible to him, it may mask some sounds of speech or music which he wishes to hear. It may also distract his attention, and, if he cannot grow accustomed to it, the result, after a period of use, may be mental fatigue and discomfort, followed by disinclination to use the aid any more.

Parasitic noise probably interferes adversely, in both these ways, with the use of electrical aids by patients suffering from old age deafness, although it is by no means the only source of difficulty in such cases. When an attempt is made to amplify the higher pitched components of speech sounds, especially consonants, those components of background noise, which occur over the lower frequencies, are heard by them only too well.

Hearing-aids in churches, cinemas, and other public places.

Littler has shown that parasitic, or inherent noise tends to be most serious when a portable aid is used in an auditorium —at a public meeting, in church, in a large board-room. (The question of the use of hearing-aids in schools is discussed in detail elsewhere.) In such conditions the speakers may be at a considerable distance from the microphone and the intensity of sound reaching it is small. The patient is obliged to put the aid into its most sensitive condition by using its full power of amplification.[1] The result is to amplify in particular any noise due to a carbon microphone, the type of noise christened by the engineers as " frying."

For listening in auditoriums therefore it is a great advantage for a microphone or microphones to be placed immediately in front of the speaker or speakers and for the amplifiers to

[1] Ewing, A. W. G., Ewing, I. R., and Littler, T. S., 1936, " The Use of Hearing Aids," *Medical Research Council Report.*

be connected by long leads to telephones in the listeners' seats. For the same reason in cinemas those hearing-aid systems which are connected direct to the sound-film or record, can give the deaf patient much better results than he could possibly obtain by listening with a portable aid. In the latter case, in addition to parasitic noise, there is the disadvantage that what he hears has undergone a double distortion before it reaches his ear, first in the sound-recording process, secondly when his aid picks up and imperfectly reproduces the inaccurate version of the original sound. By eliminating his own microphone and amplifier the patient avoids the second of these sources of distortion.

Methods of testing hearing-aids.

Littler has described in the article already quoted his method of testing hearing-aids under working conditions. He has referred to some of the technical difficulties which had to be overcome, such as the provision of suitable attenuators, calibrated in decibels, for use with various hearing-aids. He also foreshadows the use of an artificial ear for testing aids as soon as their response at the highest frequencies has been improved.

Experimental hearing-aids.

The aids which were tested included selected samples of the principal non-valve types in common use and also certain experimental high-quality valve hearing-aids, designed by Littler himself, to give the most efficient reproduction of sound which could be got from the best components that were obtainable.

At the time of writing, continuous development is taking place in the design of valve aids. New and better models are frequently being made available to the public by a number of commercial firms. At least one individual aid can be obtained which can be operated from the electricity mains supply. It seems reasonable to hope that ultimately deaf people might even be able, if they wish, to buy aids approaching the standard of efficiency of Littler's group aid, discussed below.

The inclusion, in our investigations, of tests of experimental aids, was therefore of all the greater value.

First, the high standard of efficiency of the experimental apparatus served as a kind of yard-stick with which to compare the

performance of other instruments. Many or most commercial aids are necessarily designed for smallness and portability, and this is still always difficult to reconcile with high efficiency.

Secondly, known variations in the output were introduced into the test with experimental apparatus, so that the effects of changes in the relative loudness of high and low notes, respectively, could be noted. Tests were made with practised deaf patients suffering from various types of deafness. It could be judged, from the results, whether deliberate distortion of speech, as heard by these patients through the aids, was ever beneficial.

Thirdly, because of the full degree of control possible during the tests, and the very accurate reproduction of sound by the experimental aids, it became possible to envisage some of the ultimate physical limitations imposed by some forms of organic injury or defect in the mechanism of hearing, for which no conceivable form of aid can ever compensate so well as lipreading. These physical limitations, and not technical difficulties in the design of instruments, probably set the ultimate bounds to the use of hearing-aids.

An obvious instance is total, or extremely severe deafness for sound of pitch above 1024 vibrations per second. This is the range where most of the consonant sounds occur. Unless sound over the upper half of the speech range could somehow be mechanically transposed to the lower half, patients with this type of deafness cannot be helped to hear many consonants. It will be seen later that they must depend mainly or very largely upon lipreading in daily life.

It is thus improbable that mechanical aids to hearing will ever be more than one of several means of alleviating chronic deafness.

Types of hearing-aids.[1]

The following table shows the extent to which six types of hearing-aid amplify sound over the range of pitch involved in speech.

The types of aid are :

No. 1. A tortoise-shell auricle, a non-electrical form of sound collector kept in position by a headband.

No. 2. A simple battery aid of popular type, wearable on the person, without valves and having an air-conduction (moving-iron) telephone.

[1] Statistics taken from Littler, T. S., article in *Journal of Scientific Instruments* already quoted.

No. 3. An aid similar to No. 2, but which has a bone-conduction receiver.[1]

No. 4. A portable aid with two valves, carbon microphone and air-conduction (moving-iron) telephone; an aid designed by Littler.[2]

No. 5. A portable aid, with multiple valve, air-conduction (moving-iron) telephone but with transverse current microphone; an aid designed by Littler.

No. 6. A group hearing-aid designed by Littler for use in schools for the deaf; twelve or more persons can listen at once; there are four stages of valve amplification; the results here quoted were obtained during tests with a transverse current carbon microphone and moving-coil telephone; moving-coil or crystal microphones and crystal telephones can also be used.

Tabulated the figures are :

Amplification in Decibels.

Frequency.	1 Auricle.	2 Non-valve Battery Aid.	3 Bone-conduction Non-valve Aid.	4 Two-stage Valve Aid.	5 Transverse Microphone Valve Aid.	6 Group Valve Aid.
256	0 to 5	−10	0	15	20	30
400	0 to 5	10	5	25	35	45
512	0 to 5	5	10	25	35	45
700	5	0	10	30	35	50
1024	5	15	25	35	40	50
2048	0	−10	no test	40	30	50
3000	−5 to 0	−10	−10	35	20	45
4096	−5 to 0	−25	− 5	10	5	40

The differences in efficiency which are here put before us will be seen at once to be of a very striking order. There is a gulf

[1] When this book was sent to press the only available valve aids with bone-conduction receivers were experimental. New instruments of this type, however, may now be obtained by deaf patients. They reproduce speech much more accurately.

[2] A circuit diagram and constructional details of this instrument were published by Littler in an article, "Hearing Aid for the Deaf," *Wireless World*, April 17th, 1936. Similar details of Nos. 5 and 6 are included in his article in the *Journal of Scientific Instruments*, already quoted. All the aids have been widely used during recent years, Nos. 4 and 5 by individual patients, and No. 6 in about fourteen schools for the deaf in England and Wales. Details of additional aids are now in the press.

fixed between the output of the best of the non-valve aids on the one hand, i.e. the instrument with bone-conduction receiver, and the valve aids on the other. The disparity suggests comparison with the superiority of electrical over non-electrical reproduction of gramophone records, or of all-mains wireless receivers over crystal sets.

The non-valve aids all afford help to the listener over some part of the speech range but, at the same time, they all diminish the sound heard by the deaf patient in one or more other parts of the range. They give, as it were, with one hand, but with the other they also take away, to a lesser or greater extent.

It is convenient to analyse these amplification curves under the two heads of loudness and distortion.

Performance of non-valve and valve aids contrasted: (a) loudness.

The amount of help which individual patients consider to be enough to justify the trouble and expense involved is always a matter of personal opinion. One patient, a young woman of independent means, refuses to use any aid although, with the help of a suitable modern valve instrument, she can follow conversation with approximately the efficiency offered to the ordinary present-day telephone subscriber. On the other hand, an older woman, whose livelihood will be lost if she ceases to be able to interview business callers, employs an aid to supplement lipreading although it gives her little more than an indistinct sound of voices.

Professional and expert advice cannot be the last word, but it should be fully available to the patient. It should be scientific and impartial, and thoroughly well informed.

It is best to begin to compare the performance of hearing-aids from the point of view of the patient who hears no sound of speech with the unaided ear, and will obtain an instrument if it will only enable him to hear voices in quiet conversation. To put the same point another way, how deaf can a patient be and yet derive some help from each type of aid?

All the aids, it will be seen from the last table, are at their best when reproducing sound about the pitch of 1024 vibrations per second. This is in the middle of the range of pitch, 700 to 1500 vibrations per second, over which speech sounds are loudest. (The detailed data about the loudness and intensity of speech already given in Chapter VIII will be helpful at this point.)

No. 6, the group aid designed by Littler, would render the loudest vowels in average quiet conversation (at 60 phons) audible, or partially audible, to patients with a maximum degree of deafness of about 110 decibels at 1024 vibrations per second. That would be subject to their being able and willing to listen to speech at 120 phons, which is equal to the level of noise falling on the ear in the proximity of an aeroplane engine.

Our tests have proved that actually 110 phons is the maximum loudness level to which speech can be magnified with satisfactory results for deaf listeners. Sometimes a lesser level, of not more than 90 phons, is the highest which gives maximum intelligibility. In daily use, therefore, it is customary to reduce the amplification of the group aid to less than full capacity unless the voice of the speaker is below average strength.

We must say that, in practice, with the group aid, the loudest speech sounds will be partly heard by some patients with 100 decibels loss at 1024 vibrations per second, who can benefit from speech amplified to the level of 110 phons.

No. 5, the valve aid with transverse current microphone, is capable of giving a similar degree of help to patients with the same amount of severe deafness, if used at its full power.

No. 4, the two-stage valve aid, has almost the same amplification at 1024 vibrations per second as No. 5.

When we come to the non-valve instruments, we find a sharp drop in capacity to help. The best of them, No. 3, enables a patient with a maximum of 75 decibels loss at 1024 to hear some of the loudest sounds in quiet speech. Experiment has shown that vowels must be at least 10 decibels above the listener's threshold to produce anything more definite than a vague sensation of noise.

No. 2, the non-valve battery aid of popular type, will give the same degree of limited help to a patient with a maximum of 65 decibels loss.

No. 1, the non-electrical auricle, affords some limited benefit to patients listening to quiet conversation, with a maximum loss of 55 decibels.

By speaking with more than average loudness, or very close to the microphone or auricle, it is possible to make deafer patients hear some sound with aids Nos. 1, 2 and 3. On the other hand, in large rooms and public places, speech often falls *below* the 60 phons, conversational level.

Bell Telephone Laboratories, as reported in Chapter VIII, have found great variations in the loudness of individual voices, stressed and unstressed syllables, and between the loudest vowels and the weakest consonants. The deaf patient, in ordinary conversation, is liable to meet an extreme range of variation, in the intensity of speech sounds, of the order of 56 decibels.

What has been said here about each kind of aid in no way indicates the extent to which it makes speech *intelligible* and *distinct*. Before coming to any final conclusion it is necessary to study the extent to which different types of aid distort sound.

Performance of valve and non-valve aids contrasted: (b) distortion.

In the last section the performance of all the aids was studied at the pitch at which they give the most amplification of sound. In efficiency over the rest of the speech frequency range there is a yet greater contrast between the valve and the non-valve aids. Diagram 27 and table of figures show that the non-valve aids amplify in such an uneven way as to cause serious distortion.

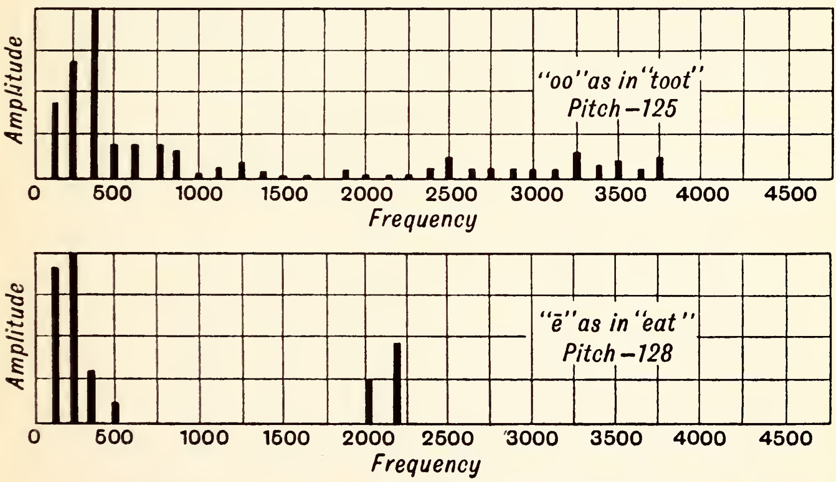


DIAGRAM 27.—Acoustic spectra for "oo" and "ee".

The effect of this distortion on vowels becomes strikingly apparent when graphically represented. In the above diagram an accoustic spectrum of the vowel "ee" as in "eat"

is contrasted with a similar spectrum of "oo" as in "toot." Both were uttered by a male voice at approximately the same pitch, "ee" at 128 vibrations per second and "oo" at 125.[1] The most noticeable difference between them is in the frequency range 2000 to 4000 vibrations per second. Here "oo" has numerous widely distributed components of small amplitude, whereas those belonging to "ee" are few (only two in this particular spectrum), close together and relatively large.

Normal listeners find it difficult to distinguish between the two vowels when these components are eliminated by means of sound filters.

It is clear that the non-valve aid actually reduces the intensity of the critical components in the 2000-4000 range of frequency, so that the deaf patient would hear them better with the unaided ear. The portable valve aid magnifies them all, though not in even proportion.

Reference to a table containing the characteristic frequencies of vowel sounds shows that the case of "oo" and "ee" is not unique. Fletcher has compiled the following composite table after comparing data given by Stumpf, Miller, Paget and Crandall. It indicates that the most important differences between the sound of vowels are found in two regions of pitch, an upper and a lower.

Characteristic Frequency of the Vowel Sounds.[2]

Speech Sound.		Low Frequency.	High Frequency.
ū	(pool)	400	800
u	(put)	475	1000
ō	(tone)	500	850
a	(talk)	600	950
o	(ton)	700	1150
a	(father)	825	1200
a	(tap)	750	1800
e	(ten)	550	1900
er	(pert)	500	1500
ā	(tape)	550	2100
i	(tip)	450	2200
ē	(team)	375	2400

We know from the experiments with gramophone records, described earlier, that normal listeners find the distinctions between vowels much impaired when the upper frequencies are suppressed by means of sound filters. To what extent

[1] Fletcher, Harvey, *Speech and Hearing*, pp. 52-4.
[2] Ibid., p. 58.

this holds good both with deaf and normal listeners will be shown more fully in the next chapter.

Amongst the 12 vowels given in the above table 6 have high-frequency characteristics at or above 1500 vibrations per second.

Similar tables prepared by Fletcher indicate that consonants, which are much more complex in character than vowels, almost invariably have important high-frequency characteristics, with an upper pitch limit of 8000 vibrations per second in the case of " s." The possible exceptions are " l," " r," " m," " n " and " ng."

It is most satisfactory to deal with the extent to which incomplete reproduction or deafness reduces the distinctness of speech by reference to statistics of intelligibility tests with human listeners. This will be done in the following chapter.

The tables make it clear also that each of the two types of non-valve electrical aid tested succeed in magnifying sound at and below the pitch of 1000, but in an uneven manner. There is a tendency to exaggerate some vowel components in an arbitrary way.

It may be asked whether the listener who habitually uses an aid which behaves like this can learn to interpret the distorted speech which he hears. Detailed evidence which answers that question will be found in the next chapter. It is only possible, at this point, to observe that the number of vowels and consonants in English is large, and that the reproduction of only half or a quarter of the range of pitch normally involved in speech gives little room, as it were, in which significant differences can occur.

In conclusion, the writers feel obliged to refer to a question, which may be asked by deaf listeners, whether the construction of non-valve electrical aids can be modified to any very marked extent. In the same way it may be suggested that by a significant alteration in the output of non-valve aids, they may be made markedly more suitable to the needs of patients.

In answer it is best to quote from the 1936 *Medical Research Council Report*, " The Use of Hearing Aids," already mentioned elsewhere. It says : " Until amplification of a higher order than has yet been achieved is possible over the whole speech range, methods of testing the possibility of matching an aid to a hearing loss curve are not possible. Claims that it is possible to do this with small aids are absurd."

CHAPTER X.

TESTS OF THE INTELLIGIBILITY OF SPEECH.

Intelligibility tests as a basis for the classification of deaf patients.

THE kernel of the problem of defective hearing is the individual patient's capacity to understand what is said to him, whether he uses an aid, depends on lipreading or is able to obtain help and relief from both sources.

Given accurate methods of testing ability to hear and to lipread speech, and enough results of carrying them out with every kind of patient, we have a foundation upon which reliable advice to any particular deaf person may be given with confidence.

The most satisfactory basis upon which to organise all the necessary statistics is the classification of all patients, in the first place, into groups, according to the score or percentage of accuracy which they achieve in intelligibility tests, with and without hearing-aids.

We may also estimate, from a comparison between the frequency response curves of aids, such as were given in the last chapter, and the results of intelligibility tests carried out with typical and practised deaf subjects, how much benefit they will offer to a patient belonging to any one group.

The focus of interest, because of its urgent importance to the deaf, will be an analysis of factors, apart from total deafness, which have been found to prevent the successful use of a hearing-aid.

Earlier voice and whisper tests.

It has long been agreed that though reliable tests of hearing which involve the use of actual speech would be eminently desirable, much at least of the usual procedure is in practice unsatisfactory.

Physicists warn us, for instance, that in some rooms, owing to their acoustic properties and the reflection of sound from hard surfaces, speech may be heard more loudly at certain points than at others. In such cases a voice test carried out at a greater distance between speaker and listener may give at least as good if not better results than are achieved at a shorter distance.

The problem of controlling the loudness of voice used in such tests was recognised as a stumbling-block long before the information about the physical nature of speech, quoted in previous chapters, was available.

In 1927 Dr. D. Macfarlan,[1] an American worker, who recorded the results of 1340 voice tests, concluded that "... so many variables in the voice test have been cited that it seems that its merits must be overshadowed by its faults." Yet he also said: "It is reasonable to retain the test in spite of its variables, for as speech-hearing is the most important function of the ear, and as the voice test uses as its hearing stimulus the very thing which is most important to test, one is dealing with a direct method. Other auditory tests cannot test speech hearing as well, for they can but test simple, single auditory qualities."

Since those words were written, however, a technique has been found which enables the variables in voice tests to be controlled. For the organised and prolonged investigation which tracked down the factors which caused inconsistencies in the past, and which resolved their influence into mathematical statements, we have once more to thank Bell Telephone Laboratories, New York.

The most important paper on the subject is probably that published by Fletcher and Steinberg in 1930 under the title of "Articulation Testing Methods."[2]

It is upon this basis that we have given two forms of intelligibility tests to deaf patients. The first is a form of laboratory test carried out with practised subjects. The second is a shorter method of testing, inevitably less refined in accuracy, but reliable for clinical use.

[1] Macfarlan, Douglas, 1927, "The Voice Test of Hearing," *Archives of Otolaryngology*, 5, pp. 1-29.

[2] Fletcher, H., and Steinberg, J. C., 1930, "Articulation Testing Methods," *Journal of the Acoustical Society of America*, 1, Supplement, pp. 1-97.

From the data obtained by Fletcher and Steinberg, followed by the Manchester tests of deaf people, it is clear that to control the loudness of the voice is not the only problem in voice tests. Of fully equal importance is the choice of the words, sentences or other test material. This is because of that capacity of the human mind, which has been discussed in Chapters II and IV, to interpret speech even when it is imperfectly heard, provided that it is familiar in thought and expression.

Macfarlan generally used numbers and selected familiar monosyllables as test words. In the more recent tests meaningless syllables, e.g. " skis, mup, toz," built up on systematic principles, play a great part. The need for them has become clear as the result of investigations which will be described.

Methods of testing intelligibility.

(1) *Casual conversation.*

The writers were once present at a demonstration of the help given by a particular hearing-aid. The basis of test was chiefly casual conversation. The demonstrator said, " Can you hear everything ? " and " You hear me quite clearly now, don't you ? " It is true that at the end of the test two or three place-names were brought into the conversation, but so far as it was possible to judge they were chosen haphazard and were not intended to determine the patient's final decision about the effectiveness of the aid. He was not told if he made mistakes and could only be aware of any if he experienced a sense of difficulty.

The nett result of the test was clearly to make the issue depend chiefly on the patient's own judgment about the quality of reproduction—whether, in his opinion, it was natural. His state of mind was shown by his remarks, " That is more natural," etc. There was no numerical check on the accuracy with which the details of speech were heard.

The personal judgment of listeners as a basis of intelligibility tests was studied by Grinsted,[1] who was looking for a method by which to assess the efficiency of telephone transmission. He was forced, however, to abandon it as a serious form of test. He writes : " This scheme is open to the objection that

[1] Grinsted, W. H., 1937, " The Statistical Assessment of Standards of Telephone Transmission," Engineering Supplement to the *Siemen's Magazine,* No. 140, January, 1937.

different persons have astonishingly different reasons for 'preferring' one circuit to another, some of them not at all dependent upon essential characteristics of transmission."

The writers have found that deaf patients who say after a few casual sentences that they have "heard everything" are sometimes completely nonplussed by a change of subject or an unexpected proper name. It is probable that most patients can only form a reliable opinion about the benefit which an aid gives them when they are much experienced in listening through very good instruments. This more than ever holds good when a patient has suffered from defective hearing over a long period. He may then have completely forgotten the sound and quality of normally heard speech.

It is far better that a trained worker should make standardised tests and advise the patient, after actual demonstration, in what conditions and up to what limit a particular aid can give benefit.

(2) *The listener's experience of difficulty.*

The material employed by Grinsted for testing the intelligibility of speech over telephone systems consisted of test sentences. The listener was asked to record the number of times he experienced a sense of difficulty in understanding what was said.

This method appears to have given satisfactory results in conditions where hearing was comparatively easy, but many deaf patients, who can be given useful help, cannot be enabled to hear *easily* even with the best hearing-aid.

(3) *Standardised sentences.*

The use of standardised sentences for testing telephone transmission was thoroughly investigated in Bell Telephone Laboratories by Fletcher and Steinberg.[1] In an earlier account [2] of the principles upon which these sentences were drawn up Fletcher says that they were "simple interrogative and imperative sentences . . . designed to test the observer's acuteness of perception and to minimise demands upon his intelligence. The questions are of a self-evident nature, the

[1] Fletcher, H., and Steinberg, J. C., 1930, "Articulation Testing Methods," *J. Acoustical Society of America*, vol. i, Supplement, pp. 1-97.

[2] *Speech and Hearing*, pp. 264-5.

answers being frequently implied in the questions. They vary in length from about five to twelve or more words, each sentence containing four or five ' thought ' words. These ' thought ' words must be correctly perceived in order to understand the idea of the sentence. Various topics covered by ordinary conversation are represented. . . ." Sample sentences are :

" 1. Name a prominent millionaire of this country ?
2. How large is the sun compared with the earth ?
3. Why are flagpoles surmounted by lightning rods ?
4. Give the abbreviations for January and February ?
5. Name the tree on which bananas grow ? "

This is obviously a more efficient method than casual conversation, because the results of such tests can be added up, averaged and treated statistically. It is all the better if the acoustic conditions can be controlled in detail : if, for instance, the sentences are transmitted to the listener by an amplifier, and if the speaker adjusts the loudness level of his voice to a standard level with the help of an output meter which measures the amount of electric current generated by it.

In laboratory tests the loudness level with which speech reaches the listener can be further regulated by means of an attenuator system or volume control, calibrated in decibels. Such a method of testing intelligibility has the advantage that it measures hearing in working conditions, in sentences which can be uttered with normal intonation, stressing and phrasing.

(4) *Nonsense syllables.*

Ultimately, in Bell Telephone Laboratories, after the fullest investigation, it was found best to use nonsense syllables, or logatomes, in making basic tests. The chief reason for the choice of meaningless words was that they proved to be the most searching probe of the efficiency and distinctness with which speech is heard.

It turned out that standardised sentences can be interpreted correctly, when, in point of fact, the listener is not by any means being given a complete and perfect version of speech.

This is due to the great capacity of the listener with normal hearing and experience to fill in, from his previous knowledge and from context, those details of speech which he fails to hear.

For instance, in the sentence " He was drinking a cup of tea," the words " drinking " and " tea " guide the listener's mind to interpret the fifth word as " cup," even if the " p," which is a consonant of weak intensity, is almost inaudible. In tests with a nonsense word, e.g. " Can you hear hep ? " the listener is given no help from context. Quite possibly he may think that the word spoken was " het," or " hek," or " hap," or something else which is not what was really said.

After studying a statistical analysis of the English language, Fletcher and Steinberg found that the con-vow-con (consonant-vowel-consonant) type of syllable was the most common. The following sample test-sheet has been used in our laboratory tests, and was drawn up on Fletcher and Steinberg's plan :

List 6

THE VICTORIA UNIVERSITY OF MANCHESTER.

DEPARTMENT OF EDUCATION OF THE DEAF

New Standard Testing Lists

(*Laboratory Tests*)

Date .... Threshold Test.
Experiment .... Right
Note Book Ref. .... Left
Caller ....
Listener ....
Remarks ....

Can you hear me say	kuch	skup	rab	theg	veech	sim
Write down the word	sef	mawj	juzh	maym	ket	shusk
The next word is	chood	yis	nop	shon	skoob	mawg
Listen to the word	nav	toasp	koav	pid	luz	gosp
I am now saying	gon	laysh	skis	lawsh	yahst	feel
Can you hear the sound	rawng	shost	sawsh	dahch	shok	roov
After that comes	jaysk	beezh	hool	sooz	thad	jeng
Another word is	theek	bag	fayng	zusk	bayj	tahn
You will now hear	hit	voom	gahj	vok	hoaf	choap
I am now calling	dahth	zez	cheef	yast	dawth	nas
The following word is	foal	sahb	teth	beet	zish	payzh

The speaker, or caller, must be acquainted with the pronunciation which the spelling of the syllables is meant to indicate. Thus "sef" is to be pronounced with the "e" as in the word "met," and "nav" also is said with a short "a" as in "hat." The substitution of nonsense syllables for meaningful monosyllables, in which no such difficulty would occur, was found to be fully justified. Ordinary monosyllabic words had been employed in Bell Telephone Laboratories in an earlier investigation.[1]

The lists are prepared from 11 vowels, 22 initial and 22 final consonants, and so included most of the vowels and consonants in common use.[2]

The testing syllables are formed in the following way:

Cards upon which the initial consonants are written are placed in one box; others, upon which the vowel sounds are written are placed in a second box; and those upon which the final consonant sounds are written are placed in a third box. A card from each box is drawn at random, thus forming the con-vow-con syllable. By drawing all of the sounds a list of 22 syllables is formed. This process is repeated three times, to obtain a list of 66 syllables, which is a unit that has been found convenient to use. A list of syllables of about this length can be used without giving callers and observers a rest period. In such a list each initial consonant occurs three times, each vowel six times, and each final consonant three times.

"In forming such syllables . . . those which represent slang are omitted. These omissions are made by returning the card upon which the sound in question is written to its box and drawing another card. By combining the sounds at random, in this manner, any desired number of lists may be made, which, for practical purposes, are all of equal difficulty."

The short introductory sentences, "Can you hear me say?" etc., are used in the test both to make the pronunciation of the test syllables natural, which they could not so well be if spoken singly, and also "to ensure that any element in the transmission system being tested, whose performance depends particularly upon its immediate past history, will be in the

[1] Fletcher, Harvey, *Speech and Hearing*, p. 263.

[2] Fletcher and Steinberg refer their readers to Krapp, 1919, *Pronunciation of Standard English in America.* Oxford University Press. Also to the Revised Scientific Alphabet, Funk and Wagnall's Dictionary.

condition in which we are interested for determining speech transmission capabilities."

Initial consonants, especially stop and fricative consonants of short duration, were found by Fletcher and Steinberg to be heard more accurately when the introductory sentences were used.

In the latest Manchester tests it has proved easier to the speaker to repeat the same introductory sentence, " Write down the sound " every time. This enables him to adjust the loudness of his voice, by watching the movements of the output meter while he is saying the introductory sentence, with a finer degree of accuracy than if the sentences are varied. He guides himself by the voltage generated by the loudest vowels as measured by the output meter. These vary considerably in intensity. It is much less difficult, therefore, to repeat one sentence many times in a uniform manner, than to attempt the same result with a variety of sentences.

The speed of utterance in the Bell Telephone Laboratories investigation was 15 sentences per minute. In our tests they are uttered slightly less quickly, at 12 per minute.

Preliminary practice for both callers and listeners is always needed to obtain very accurate and uniform results. Fletcher and Steinberg were able to employ a number of " testing crews," and they had at least a month's practice together. Such intensive preparation has not been possible with deaf and normal subjects at Manchester. The principle adopted has been not to accept the results of any experiment as final until it has been repeated often enough for them to steady down to uniformity and for the early inconsistencies due to inexperience to be eliminated.

Intelligibility of sentences and nonsense syllables compared.

One of the most interesting facts about these tests has already been mentioned, namely, that sentences can be recognised correctly even when they are very imperfectly heard.

Fletcher and Steinberg found that with the same callers and listeners, in identical conditions, a score of 100 per cent. " or nearly so," could be got when nonsense syllables were only 60 per cent. accurately heard. A score of 90 per cent. on sentences was possible when the percentage of syllables was only 30.

This makes the whole subject of the greatest importance to the deaf. Its significance lies in two directions.

Firstly, it is very encouraging to know that the normal human mind is so adaptable that it can construct whole sentences and whole thoughts from hearing, or as we shall see lipreading, only some of their parts. One aspect of adjustment to deafness, through lipreading, is the development to the maximum degree possible of skill in "putting two and two together." The same skill is valuable in the case of partial hearing. The patient who has become deaf need not hear or lipread every sound to be able to follow a conversation, but, and this must never be forgotten—the more sounds he hears or lipreads, the less will be the mental strain. It is easier to drive a car in clear sunshine than on a dark, foggy night.

Secondly, there is the other side of the question. A patient, whether child or adult, who has never heard a complete and distinct version of speech, cannot carry out this business of filling in the gaps in the same way or to the same extent as the individual with a background of normal experience. For the child born severely deaf, or who becomes severely deaf during the years most important in speech development and general education, a complete version of the sounds of speech as it is heard by the rest of the world, has no existence, unless it can be given him through a powerful and very accurate hearing-aid.

Because hearing speech imperfectly results in talking imperfectly (apart from the counter-influence of much skilled teaching), it is always urgent that any aid to hearing should be the most efficient and accurate that can possibly be used in the circumstances.

For the research or clinical worker the fact that 40 per cent. of error is undetected if sentences are used in intelligibility tests is a very important consideration.

(5) *Intelligibility tests with called numbers.*

Called numbers such as "one," "four," etc., have the advantage of being real words. The results of tests with them are capable of statistical treatment. They are learned at an early stage even in the education of the dumb child who is admitted to a school for the deaf.

Unfortunately, even more than sentences, they fail as a searching probe of the clearness with which speech is heard.

Tests with deaf children and adults have shown that numbers can be heard 90 to 100 per cent. correctly when a test with nonsense syllables, under the same conditions, reveals that consonants are being heard with less than 25 per cent. accuracy. Numbers can even be recognised 90 per cent. correctly with a vowel score below 80 per cent.

The reason is not far to seek.

In making tests with called numbers it is usual to keep to the numbers 1, 2, 3, 4, 5, 6 and 8. This is a very small number of possibilities and the listener's task is much simplified. One very expert listener has noticed that these numbers can be recognised by their duration and loudness almost apart from the pitch range over which their components occur.

Standards of intelligibility. Normal listeners.

In the New Standard Testing Lists, consisting of nonsense syllables, we have the means to make searching investigation of the degree of accuracy with which deaf and normal listeners hear speech.

Before inquiring how far aids can help patients suffering from varying degrees of hearing loss, it is well to ask to what standards of intelligibility normal people are accustomed in everyday life.

In ordinary quiet conversation some consonants, especially " v " and " z," " th " and " f," are not always distinct.[1] The best recorded results of tests which were made by direct transmission through the air, without mechanical reproduction, were obtained with the lips of the speakers 30 inches from the ears of the listeners. These results are reported by Fletcher and Steinberg in their paper already quoted. The tests were carried out in a small room with a capacity of 1000 cubic feet. Nonsense syllables were then heard with an accuracy of 98·2 per cent.

" Practically identical " results were obtained with a specially designed telephone system which transmitted and reproduced sound accurately and uniformly over the range of pitch from 100 to 4500 vibrations per second, at an intensity of 70 decibels above the normal threshold of hearing.

Women are more difficult to hear than men, and the difference in the results obtained with men and women callers

[1] Fletcher, Harvey, *Speech and Hearing*, pp. 272-6.

respectively is greater when tested over telephone systems than in listening with the unaided ear.

Fletcher and Steinberg give the following table of results for men's and women's voices, on tests carried out (*a*) with the unaided ear, and (*b*) with a telephone system, in which the microphone was of carbon type. The callers spoke with lips 1·5 inches from the microphone and the sound falling on the listener's ear reached a maximum intensity of 70 decibels.

Tests of Intelligibility, Unaided Listening, and over a Telephone System.

	Direct Air Transmission. Average Articulation of Sounds (for 21 consonants)	*Telephone System.* Average Articulation of Sounds
Men	98·2	87·5
Women	94·6	80·5

It is improbable that the standards of intelligibility for unaided listening given here are often equalled in daily life. The many sources of variation discussed in Chapter VIII prevent that. It has been stated that in large rooms and public places " the level of sound at the ear is often quite low " and the " higher frequency components . . . are usually weak by the time they reach the ear, due to selective absorption in the room."

Modification of technique with deaf listeners.

For clinical and classroom use a Short Intelligibility Test has been evolved.

It has been given to 90 deaf patients. The much longer laboratory tests with the New Standard Testing Lists have been carried out with 20 deaf listeners. Both forms of test were made with 8 patients. The ages of these deaf people varied from 7 years to 82 years. The longer test was made with only one pupil under 15 years of age. That was an exceptional instance, which will be described fully later. All the patients were also tested with a pure-tone audiometer and a detailed comparison of hearing for speech with hearing for pure tones is therefore possible in every case.

Some modification of the procedure, used in making tests of the intelligibility of speech to normal subjects, is needed in testing deaf listeners.

Special precautions are required to make an accurate record of what the latter have heard.

It is not satisfactory with many young deaf pupils, or with some adult patients, for the subject to write down what he hears. It may not be possible within a reasonable amount of time, to teach him how to spell nonsense syllables.

The alternative is that he should repeat each syllable aloud and that a trained assistant should do the writing. This has been found the most satisfactory technique. It is a good plan for the deaf subject to overlook the assistant's written record so as to eliminate mistakes, which may otherwise arise when his speech is defective because of his deafness. Most of the pupils tested had been trained in the symbols used by the International Phonetic Association. The procedure followed in testing them is that :

(1) the subject repeats aloud what he thinks he has heard ;
(2) the assistant, watching the listener's mouth as well as listening to him, writes down what he has said in phonetic symbols ;
(3) the subject at once reads what the assistant has written, to make sure that the latter has heard, and lipread, him accurately.

This technique seems to reduce to the minimum the chances of mistakes in recording.

At first deaf patients, and especially deaf pupils who have been taught speech, usually attempt to construe meaningless syllables as normal and familiar words. This is to be expected and is of course encouraging evidence of the extent to which the specialised education which has been given to them has been successful. In daily life they need the utmost degree of skill in constructing whole sentences and thoughts from speech [1] which they have been able to hear or lipread in part only.

Some readers may ask whether it would not be better, in spite of all difficulties, to devise a method of testing the intelligibility of speech to deaf patients which would measure these powers of mental synthesis. The answer appears to be, that it is much more efficient to measure intelligence, extent

[1] See Chapter III.

of vocabulary and educational attainment by special and separate tests.

To the writers, a method of finding out how far the details of speech are perceived, by hearing, by sight or by both senses together, seems indispensable. That meaningless syllables are the most searching form of intelligibility test for normal listeners has been shown in a previous section of this chapter. With deaf patients the same reasons hold good. There is also the added consideration that no ordinary meaningful material can be found which offers even approximately equal difficulty to patients of different ages, of different standards of intelligence and with varying attainments in speech and general education.

Short intelligibility test.

Full details of this test will be found in Appendix B. There are three sections. The first consists of 20 numbers which are called to the patient in pairs, e.g. " two, four," " six, one." This part of the test is introductory. It gives preliminary practice and its results are a rough check on those obtained in the following sections.

The second section is made up of 10 monosyllables consisting of vowels only, e.g. " aw," " $\overline{\text{ee}}$," " $\overline{\text{oo}}$." In the third are 10 syllables designed to test hearing for consonants. The same vowel is used in all of these but it is prefixed in each case by one of 10 consonants. These were chosen partly on the basis of their intensity, as given in Table on page 106. Consonants which are difficult to distinguish when imperfectly heard, especially " th," " b " and " v," " sh " and " j," were purposely included, to compensate for the relatively smaller difficulty of the whole test, when compared with the New Standard Testing Lists already described.

Repetitions of each section are made possible by rearrangement of the order of the numbers and syllables. The rate at which the syllables are called is approximately one per second.

In the construction of the short test it has been a question of finding a compromise between material and methods which would make it as searching as possible, and, on the other hand, the limits of what can be readily understood, and efficiently carried out by patients of almost any kind at one sitting. In

many cases only one visit to the clinic can be made, since a large proportion of patients come from a distance.

The intensity level at which the Short Intelligibility Test is made is approximately 65-70 decibels above the normal threshold of hearing.

This was approximately the level of loudness at which the New Standard Testing Lists were given to normal listeners in the investigation by Fletcher and Steinberg. It is therefore a convenient zero level upon which to work out standards of intelligibility which may hold good for all listeners, deaf and normal.

It must be emphasised, at risk of repetition, that a patient who is only just able to follow conversation at the intensity level of 65-70 decibels above normal threshold, cannot with the unaided ear interpret quiet conversation at 55-60 decibels. He is unable to hear general conversation or speech in an auditorium.

The tests of the intelligibility of speech which have been made *without* hearing-aids, have been carried out with the lips of the speaker 36 inches from the listener's better ear. In the clinic the principal tests *with* hearing-aids have been made with the same distance between the speaker and the microphone of the aid. Both speaker and patient remain in the same positions in the room for these tests. When needed, additional tests are made at greater distances to find whether the patient is likely to benefit from the use of an aid in an auditorium.

In the laboratory further experiments have been conducted with the speaker at 12 inches and at 40 inches from the microphone and with the intensity of speech, as heard by the listener, adjusted as required by means of an attenuator or volume control.

The standard intensity level of 65-70 decibels, at which the test material has most often been spoken, involves a slightly raised voice, not a shout. The tests are all made by clear speakers, trained in teaching deaf children through hearing-aids.

Laboratory tests have shown that there is a close degree of uniformity in audibility and intelligibility amongst the workers who have made the tests.

In daily life the patient does not often encounter such clear speakers. In our clinic each patient is warned of this when the

tests are completed. On the other hand, the consonant-vowel section of the short test (and of course the New Standard Testing Lists) is very exacting, because of the absence of all help from context. It is better to make this test in standardised conditions and with standardised speakers than in poorer conditions and with speakers whose articulation falls short of professional efficiency to an extent which cannot be at all accurately estimated.

The results of the tests are found to give a series of four grades of deafness to speech, readily comparable with the standards for normal listeners worked out in Bell Telephone Laboratories.

Methods of scoring intelligibility tests.

The accuracy with which the listener hears consonants is more important than the accuracy with which he hears vowels. Although vowels are always more easily recognised, consonants occur far more often.

Several formulæ have been used to give weight to the consonant scores in intelligibility tests made with nonsense syllables. The simplest is stated by Davies: "A figure of merit, expressing for every individual the value to him of a particular hearing-aid, is obtained by multiplying the percentage of vowel sounds he hears correctly by the percentage of consonant sounds and again by the percentage of correct consonant sounds." [1]

The formula of Fletcher and Steinberg [2] is

$$S = 1 - (1 - V_w C_w^2)0{\cdot}9,$$

where S is the standard syllable articulation, V_w the vowel articulation, expressed as a ratio, and C_w the consonant articulation, expressed as a ratio.

Examination of the results of the Short Intelligibility Test with 90 deaf patients shows that they may be graded with a considerable degree of accuracy mainly on their ability, or inability to hear consonants. This is convenient for clinic work.

[1] Davies, A. H., 1934, *Modern Acoustics*, p. 308. G. Bell & Sons Ltd.

[2] Fletcher, H., and Steinberg, J. C., 1929, *Bell System Technical Journal*, vol. 8, p. 806; and 1930, *Journal of the Acoustical Society of America*, vol. 1, Supplement, pp. 40-2.

Severity of hearing loss for speech among deaf patients.

Davies, in the book already quoted,[1] reports that in telephone engineering an articulation, or proportion of accurately heard sounds, of 85 per cent. upwards, represents quite good conditions. He states that an articulation of 70 per cent. is the minimum taken by telephone engineers as practicable.

Judged by these standards the extent to which defects of hearing diminish the accuracy with which patients hear speech is very serious.

It is startling to find that, without an aid or lipreading, only 16 patients, out of an unselected series of 90, heard speech with an accuracy (or articulation) exceeding 16 per cent. This was in standard conditions, when the speaker uses an mf. to f. voice at the short distance of 36 inches from the better ear. No fewer than 42 patients heard no sound at all in this test.

Examination of the hearing-test results for 658 adult patients, who have sought help, confirms the conclusion that all but a small minority have been severely, if not totally, deaf to speech.

None of the evidence obtained in these investigations emphasises more sharply the amount of needless suffering and strain endured by many deaf people. Viewed from one aspect their endurance is in the highest degree courageous; "it is magnificent but" . . . it is not creditable to a scientific age.

As has been said elsewhere in this book, the easiest way to acquire proficiency in lipreading is by beginning to form the habit when impairment of hearing is first detected. So many of those who, in middle or later life, become severely deaf to speech might experience all the help that lipreading gives at every stage of the progress of their deafness, instead of turning to lipreading as a last resort.

Much the same thing is true of the use of hearing-aids, although they cannot give as much help as lipreading in cases of slight deafness. The parasitic, or inherent noise, made by an aid [2] limits its serviceability in such cases. Nevertheless, the statistics derived from the tests which we have made give added weight to the opinion reached by Knudsen and Jones, quoted in an earlier chapter, that the percentage of those who use aids is but a fraction of those who might and should.

[1] P. 308. [2] See Chapter IX, p. 118.

Apart from the artificial stigma which has in the past been associated in the minds of many people with the use of mechanical aids to hearing, there has been the more serious stumbling-block of their low standards of efficiency. Further evidence of the striking extent of recent improvement in hearing-aid design will now be given.

Comparative efficiency of valve and non-valve aids.

There is a great contrast between the efficiency of reliable valve aids and that of all other kinds of aid to hearing. The results of standard intelligibility tests with aids lead to exactly the same conclusions as do measurements of their sensitivity and capacity to amplify sound over the different parts of the speech range.

Auricles [1] give very little help. Speaking-tubes are much more useful, though cumbersome. Approximately 20 per cent. of the 658 adult patients mentioned in Chapter II, although they were not totally deaf, could not gain benefit from electrical aids. With a speaking-tube such patients are enabled to hear speech with about the same degree of accuracy that they experience when the speaker's lips are close to their ears.[2]

There are two advantages involved. Since a speaking-tube makes no parasitic, or inherent noise, and since it brings a quiet voice close to the ear, it can be used by nerve-deaf patients, usually elderly, who cannot endure loud sounds or noises.

Secondly, it is possible for the speaker to hold the mouthpiece of the tube in such a position that the patient can see his mouth and lipread his speech. This is very important. Lipreading is of course ruled out if the speaker is obliged to be close to one side of the patient's head.

Non-valve aids, of the popular microphone-battery-telephone type which can be worn on the person, are inefficient when tested as telephone systems, although some patients, usually with middle-ear or mixed deafness, contrive, by means of context and, often by some skill in lipreading, to interpret what they hear through them, in spite of distortion.

[1] See Chapter IX, p. 122.

[2] Compare Ewing, A. W. G., Ewing, I. R., and Littler, T. S., 1936, "The Use of Hearing Aids," Table VII, p. 38.

In the *Medical Research Council Report*, "The Use of Hearing Aids," the results of intelligibility tests with a good specimen of non-valve aids are compared with the results obtained by using a group, or classroom, valve aid.

The non-valve aid had the usual small (not midget) moving-iron telephone. The classroom valve aid is designed to work with moving-coil or crystal telephones, and a moving-coil telephone was therefore used during the tests.

Two series of tests were made with all the listeners, the first with speakers 12 inches from the microphone, the second at 40 inches.

Two listeners with normal hearing and six partially or severely deaf patients took part. One was born deaf.

The normal listeners were able to hear speech through the non-valve aid with only 57 per cent. average accuracy at both distances. This percentage is therefore much below the standard of 70 per cent. quoted by Davies as the minimum demanded in telephone systems.

With the classroom valve aid the normal listeners heard speech 100 per cent. correctly at 12 inches and with an average score of 78 per cent. when the speaker was 40 inches from the microphone.

For all the listeners the average results for the tests with the valve aid were better with the speakers at the short distance from the microphone.

For four deaf patients the average percentages were :

Intelligibility of speech : valve aid.

	Distance of speaker's lips from microphone:	
	12 inches.	40 inches.
Percentage of accuracy .	72	67

With the non-valve, popular type of aid, the difference between the results at the two distances was much greater. The average percentage of accuracy obtained by the same four partially and severely deaf listeners was :

Intelligibility of speech: non-valve aid.

	Distance of speaker's lips from microphone:	
	12 inches.	40 inches.
Percentage of accuracy .	38	17

For the deaf listeners therefore the superiority of the valve over the non-valve type of aid was shown to be even more marked than in the tests of subjects with normal hearing.

The following scheme for grading patients according to their deafness to speech is at present being tried. It is based on the results obtained when 90 unselected patients were given the Short Intelligibility Test, without hearing-aids or lip-reading. Eight patients have completed both the Short Intelligibility Test and a series of experiments with the New Standard Testing Lists.

The grades are as follows, when

(*a*) the syllables are called at an intensity 65-70 decibels above the normal threshold of hearing;
(*b*) the distance between the speaker's lips and the listener's better ear is 36 inches;
(*c*) the rate of calling is approximately 1 syllable per second;
(*d*) all possibility of lipreading is excluded;
(*e*) the speaker's enunciation is very distinct but not exaggerated.

The statements in the next section of this chapter, about the capacity of patients in each grade to hear speech, are not always applicable to those who are born deaf or who have become deaf in early childhood.

Grade I.—Five patients recognised 9 or 10 consonants correctly with the unaided ear. The corresponding articulation, or percentage of accuracy, when the New Standard Lists are used, is about 80 and upwards. In the test conditions Grade I patients therefore hear with a degree of distinctness corresponding to that which is experienced by normal listeners when using a fairly good telephone system. Unfamiliar names or unexpected turns in a conversation may cause

difficulty, but attentive listening in *tête-à-tête* conversation gives satisfactory results. Patients who recognise all the consonants correctly in the short test can often hear close conversation with something approaching ease.

Grade II.—Eleven patients heard 5 to 8 consonants correctly with the unaided ear. Most of them made some though fewer errors in the vowel section also. These patients hear indistinct or quiet speakers very badly, and variations in the loudness of speech due to acoustic conditions cause them great difficulty. When listening with the unaided ear they never reach the minimum standard of 70 per cent. efficiency which is demanded for normal listeners, even in *tête-à-tête* conversation.

Grade III.—Thirty-two patients made more than six errors in the consonant section, but could recognise at least some vowels with the unaided ear. The corresponding articulation per cent. is less than 16. These patients only follow conversation, therefore, with very great difficulty when listening with the unaided ear, even if the speaker raises his voice and comes close.

Grade IV. — Forty-two patients could hear no sound with the unaided ear in the Short Intelligibility Test. A number of them could be made to hear, though usually to a very limited extent, by a speaker talking with lips close to their better ear.

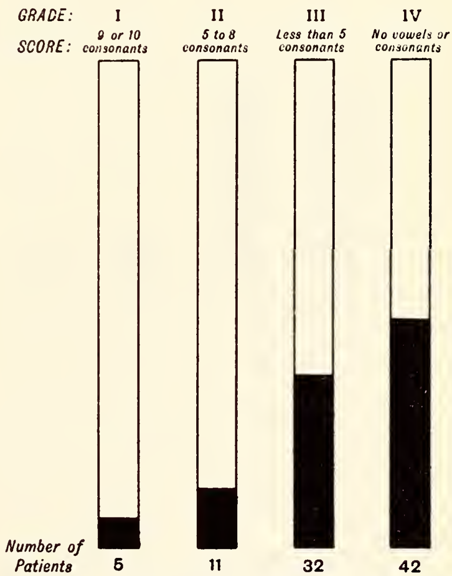


DIAGRAM 28.—Results of Short Intelligibility Tests. (Unaided ear.)

Diagram No. 28 illustrates the proportion of patients in each grade, when classified on the results of tests without an aid or lipreading.

Extent of help given by use of valve aids.

Diagram No. 29 shows the extent to which the same patients can be helped by one of three types of portable valve aids. Their ability to hear speech was again measured by the same Short Intelligibility Test, when listening through an aid but without lipreading. As a rule each patient was tested with the following aids :

(*a*) A two-stage valve aid with neophone transmitter ; [1]

(*b*) a multiple valve aid with transverse current microphone ; [2] and

(*c*) a three-stage valve aid with crystal microphone ; this was in certain respects similar to an instrument designed by Littler.[3]

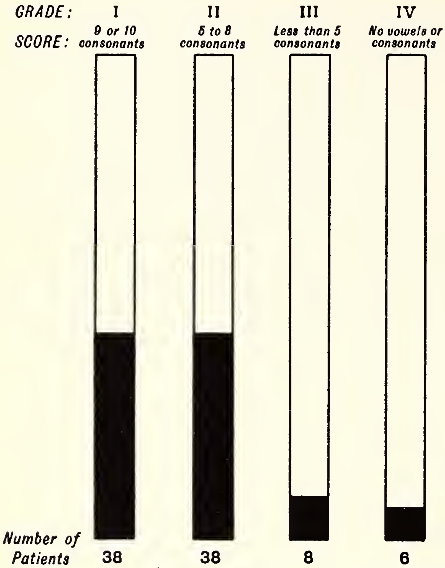


DIAGRAM 29.—Results of Short Intelligibility Tests. (With valve aid.)

The scores obtained by each patient with the different aid were compared. The highest score showed which aid enabled him to hear best and is the score on which the diagrams are based. Whenever necessary the score was verified by a second test.

Eighty-eight per cent. of the 90 patients could be given effective help. Twelve per cent., who heard no sound in the standard test with the unaided ear, could even reach Grade I efficiency with one or more of the valve aids.

The simplest method for determining the amount of benefit

[1] See Chapter VIII. [2] Ibid.

[3] Compare Ewing, A. W. G., Ewing, I. R., and Littler, T. S., "The Use of Hearing Aids," pp. 37-8.

obtained from the aids is to calculate the number of patients who were enabled to gain 3, 2, 1 and 0 grades respectively.

Approximately half the patients, 44 in all, gained two or three grades. Of the remainder, 33 gained 1 grade, 11 patients made no gain, and 4 were in Grade I when unaided.

It will be necessary to seek for the reasons which prevented patients from being helped. This can best be done in the next chapter in the course of an analysis of the results of pure-tone audiometer tests.

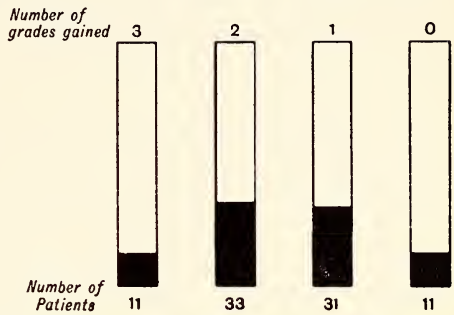


DIAGRAM 30.—Gain in Intelligibility from use of valve aid.

The satisfactoriness of this relatively simple method of grading deafness to speech has been very carefully examined from every aspect.

It is of course true that an increase of consonant score from 8 to 9, or from 4 to 5, makes the difference of one grade. To avoid such a possibility is difficult in any form of short test, when it is essential to have a section or sections for practice preliminary to the test proper. The only practical course is repetition of the test material in all border-line cases or when the behaviour of the patient gives cause for doubt.

Supposing that all vowels are correctly heard, the application of the formula quoted from Davies brings it about that whereas a 90 per cent. score on consonants is equal to an intelligibility of 81 per cent., an 80 per cent. consonant score is equal to an intelligibility of only 64 per cent., and a 40 per cent. consonant score gives an intelligibility of a mere 16 per cent. The standard set up for each successive grade does, therefore, correspond to a very real difference in efficiency.

CHAPTER XI.

HEARING CURVES AND HEARING AIDS.[1]

"Of what help are tests of a deaf patient's hearing for pure tones with an audiometer, or with tuning-fork and monochord, in the prescription of a hearing-aid?" It has been evident for some years that more precise information is wanted to answer this question. We have to analyse the available experimental evidence to find how much the results of pure-tone tests tell us about the patient's need of an aid, and his prospects of benefiting from the use of a suitable instrument. After that there is the problem whether aids can be designed to suit individual cases.

It is essential to approach these subjects with a clear conception that vowels and consonants are exceedingly complex sounds. Many of them have components spread over several octaves. The reader is asked to refer again to the acoustic spectra of vowels given in Chapter V (pp. 49-50).

Components of the vowel "ah" as in "tar," for instance, are found over five octaves. It is true, on the one hand, that the most characteristic features of this vowel are its loud components of large amplitude about the frequency of 1000 vibrations per second, of pitch approximately two octaves above middle C on the piano. Similarly "ee" as in "team" has an important group of components about the frequency of 2400 vibrations per second, or one octave higher still. These are the primary characteristics by which the listener normally identifies the two vowels.

Such is the adaptability of the human mind, however, that the sounds of speech can still be recognised with some degree of success even when they are so distorted that their primary characteristics are greatly modified or even suppressed. In-

[1] By kind permission of Mr. G. E. Archer (Honorary Otologist, Manchester Ear Hospital and Stockport Infirmary) his detailed reports on the otological examination of three patients are included in this chapter.

formation has been obtained about the influence of what we must call secondary characteristics of vowel and consonant sounds. This information is of great importance to the deaf and to those who wish to help them.

It must be understood, however, that although distortion is not necessarily incompatible with a degree of intelligibility, it always and invariably reduces both the accuracy and the naturalness with which speech is heard. It is always an objectionable phenomenon.

Distortion and the intelligibility of speech to normal listeners.

Fletcher has given an account of a prolonged series of drastic tests of the intelligibility of artificially distorted speech to normal listeners.[1]

The method was to call nonsense syllables through a high quality telephone system. Into this sound filters were introduced to suppress all sound above or below a given level of pitch.

The effect was that the listener heard speech as if he were totally deaf to all that range of sound which was thus filtered out.

A study of the results leads to one immediate conclusion which affects many deaf people: namely, that deafness to the upper half of the range of pitch involved in speech diminishes intelligibility much more seriously than deafness to lower tones.

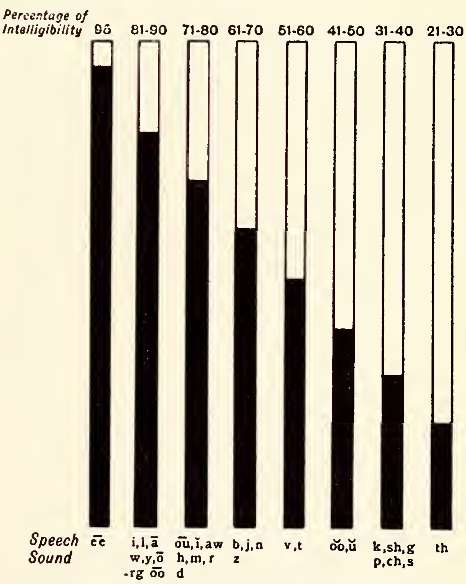


DIAGRAM 31.—Intelligibility of vowels and consonants: sound above 1000 ~ suppressed.

This fact is illustrated in Diagram No. 31.

[1] Fletcher, Harvey, *Speech and Hearing*, pp. 282-5.

It includes the results obtained with 10 vowels and 21 consonants, which were used in nonsense syllable tests, when (*a*) lower tones, and (*b*) higher tones were suppressed.

The following is a key to the pronunciation of the vowels in the above diagram :

e͞e	as in	team	o͞u	as in	bout
ī	,,	bite, time	ĭ	,,	bit
ā	,,	tape	aw	,,	bought
ō	,,	boat	o͝o	,,	book
o͞o	,,	boot	ŭ	,,	but

All the 10 vowels and 21 consonants were recognised 95 per cent. correctly when sound below 1000 vibrations per second was suppressed. It is rather surprising to find that vowels can be identified so well if one hears only their higher pitched components.

Turning to the results of suppressing sound *above* the frequency of 1000 we find detailed evidence of much loss of intelligibility. Only " ee " as in " team " can be heard with 95 per cent. accuracy. For more than half the consonants and for two vowels, " o͝o " as in " book " and " ŭ " as in " but," the chances of recognition are below 70 per cent. The two vowels mentioned, together with 7 consonants " k," " sh," " g," " p," " ch," " s," and " th," were heard correctly less than 50 per cent. of the times that they occurred in the tests.

The listener, deaf or normal, who is in the position of being able to hear sound over only the lower half of the speech range (below 1000) is therefore most gravely handicapped. Fletcher states that in this condition the intelligibility of speech as a whole drops to 40 per cent. This is much below the 70 per cent. minimum standard required in telephone transmission. It may not altogether prevent recognition of conversation in which the listener has the help of context and is familiar with the thought and the language in which it is expressed. It will necessitate attentive listening, however, and it will inevitably result in mistakes and misunderstandings. Lipreading, where possible, is absolutely essential to the patient who is deaf to sound above the frequency of 1000.

The outcome of all the tests with distorted speech, reported by Fletcher, is that vowels and consonants *can* be identified when only parts of them are heard, the parts which are higher in pitch being the most important. Occasionally their components in two quite different ranges of pitch give equal intelligibility. The consonant "p," for instance, is recognised 95 per cent. accurately when only its components above 2750 are heard, and 97 per cent. correctly from its components below 3000. The consonant "f," on the other hand, can *only* be identified 95 per cent. correctly if its components above 5000 are audible.

There are probably three classes of secondary characteristics to be found among speech sounds. They can be said to provide an emergency means, by which deaf or normal listeners may, with practice, make shift to follow what they hear.

First there is the probability that even when the principal characteristics of vowels and consonants are eliminated by deafness or mechanical distortion, minor peculiarities of pattern remain. Inspection of acoustic spectra supports this view.

Secondly, there is the fact that for very brief fractions of a second the peak power of vowels and consonants sometimes rises far above their phonetic and average power, from which their loudness is ordinarily calculated. In the vowel "ah" as in "tar" for example, the peak power rises to 80 decibels when its phonetic power is 55 decibels.[1]

Thirdly, Fletcher has remarked that consonants may sometimes be identified even though they themselves are not heard at all! The explanation of this is that they modify the vowels which they precede or follow, as the phoneticians have shown.[2] To the sounds which occur at the beginning of vowels as the result of this process of modification Fletcher gives the description "transitional."

Typical hearing curves of deaf patients.

The foregoing consideration of the complex nature of speech sounds prepares us for the discovery that the intelligibility of speech to deaf patients can be estimated from their hearing

[1] Compare Fletcher, Harvey, *Speech and Hearing*, pp. 70-1.
[2] Ward, Ida, *The Phonetics of English*, p. 60. W. Heffer & Sons Ltd.

curves with only approximate accuracy. Hearing curves are most helpful in forming an estimate of what a given individual of average intelligence and experience may be expected to hear with the unaided ear.

Audiometer test results are only threshold values, they do not indicate the effects on the patient of intense stimulation by very loud sounds. Neither, of course, do they give any clue as to his powers of sensory appreciation, or as to the extent of his previous opportunities of hearing speech in any sort of conditions.

These factors become very important in intelligibility tests made *with hearing-aids*. The combination of the effects of deafness with the effects of the imperfections of the best mechanical reproduction of speech often make it unwise to rely upon any estimate of the accuracy with which a particular patient will hear speech through an aid. We have found that a standard test with the aid, such as the Short Intelligibility Test, is indispensable.

The method which has been adopted in this chapter to find how much information, about capacity to hear speech and to benefit from the use of an aid, can be got from hearing curves, is as follows :

(1) the patients have been graded according to the accuracy with which they hear speech with the unaided ear, as shown by the Short Intelligibility Test ;

(2) hearing curves, showing the least and the greatest loss of acuity found among patients in each grade, have been chosen for representation ; where the curves differ in type one of each type is given ;

(3) the sample records have also been made to include adult patients representative of different age-groups, occupations and social experience ; children are discussed in Chapter XVII ;

(4) detailed inquiry has been made into all available data about patients who failed to obtain help from a modern valve aid, although they were not totally deaf ;

(5) evidence has been collected about the extent to which the output of hearing-aids can or cannot be modified to suit individual patients.

Grade I.—Patients scoring 9 or 10 consonants when listening unaided.

Summary :

Intelligibility test, score out of 10.

Patient.	Age.	Unaided. Vowels.	Unaided. Consonants.	Valve Aid. Vowels.	Valve Aid. Consonants.
No. 101	15 years	10	9	no test	no test
„ 102	19 „	10	10 [1]	no test	no test
„ 103	60 „	10	8	10	9
„ 104	74 „	10	9	10	9
„ 105	80 „	10	10 [2]	10	7

These patients can be helped by lipreading best, not by an aid, in conversation, but in some cases an aid is helpful in an auditorium. See p. 119.

[1] Heard only 7 consonants when tested with p. voice.

[2] Heard only 7 consonants when tested at 6 feet.

Sample audiograms and records.

Patient No. 101.

	Vowels.	*Consonants.*
Intelligibility score, unaided . .	$\frac{10}{10}$	$\frac{9}{10}$

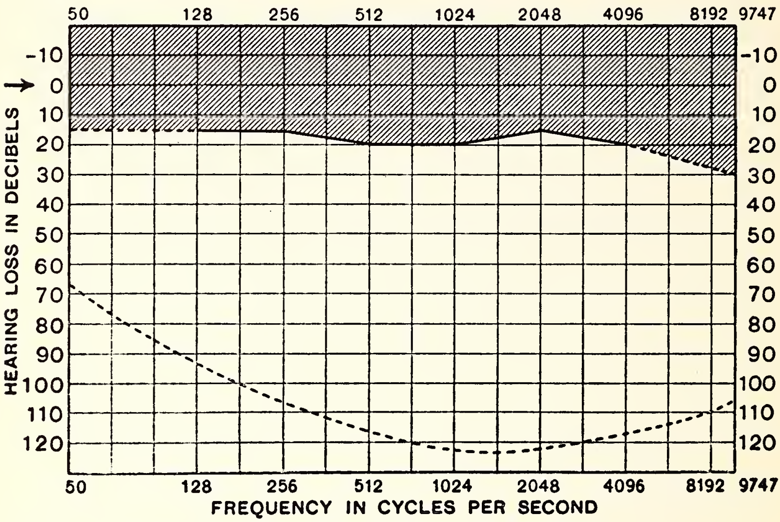


DIAGRAM 32.—Air-conduction audiogram, left ear.

Right ear	128	256	512	1024	2048	4096
	30	30	45	25	10	25

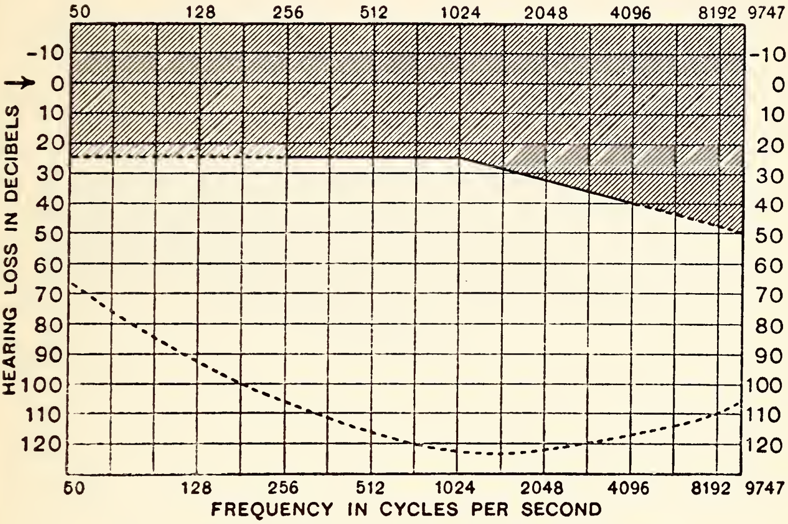


DIAGRAM 33.—Bone-conduction audiogram, left ear.

Right ear	256	1024	4096
	25	25	25

Age : 15 years.

History.—Referred to clinic by family doctor on account of complaints that he spoke very indistinctly at school. Frequently absent from school with severe colds. Mumps at $7\frac{1}{2}$ years.

Tinnitus.—None reported.

Own speech.—Unusually husky voice when talking, but less so when singing. Speech very hesitant.

Notes.—Behaviour very alert, but strained and anxious. Unsatisfactory reports from school probably due to difficulty in hearing and consequent nervous inhibitions rather than to lack of ability.

Patient No. 102.

Intelligibility score, unaided,	*Vowels.*	*Consonants.*
(*a*) mf. to f. voice	$\frac{10}{10}$	$\frac{10}{10}$
(*b*) p. voice	$\frac{10}{10}$	$\frac{7}{10}$

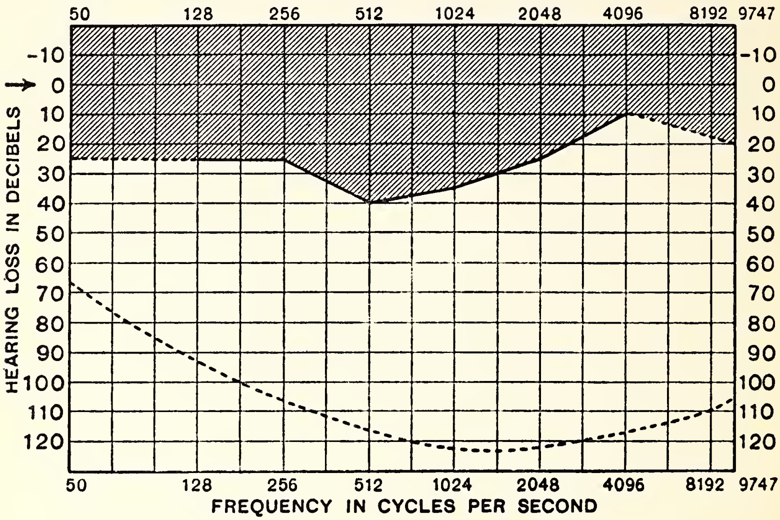


DIAGRAM 34.—Air conduction, left ear.

Right ear	128	256	512	1024	2048	4096
	40	40	45	55	30	20

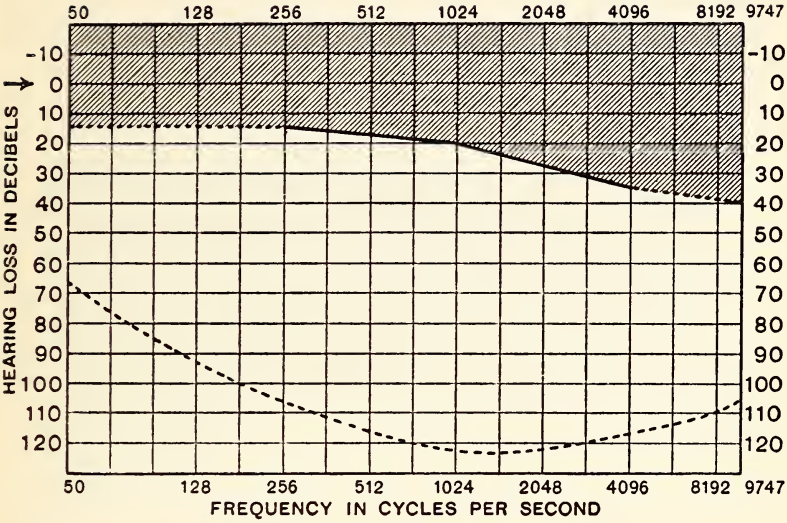


DIAGRAM 35.—Bone conduction, left ear.

Right ear	256	1024	4096
	5	20	25

Age : 19 years.

History.—University student. Otologist diagnosed progressive deafness. Older brother similarly affected. Paracutic.[1]

Tinnitus.—None noticed.

Own speech.—Normal.

Notes.—Aware of difficulty in hearing conversation when he has a cold. Cannot follow at theatre. Uses post office telephone without difficulty.

[1] The references to paracusis in these reports imply that the patient believes himself to hear better in a noise. The explanation, in some or all of the cases, may be that speakers with normal hearing raise their voices to a high level of loudness in a noisy environment.

Patient No. 103.

	Vowels.	*Consonants.*
Intelligibility score, unaided . .	$\frac{10}{10}$	$\frac{8}{10}$
valve aid . .	$\frac{10}{10}$	$\frac{9}{10}$

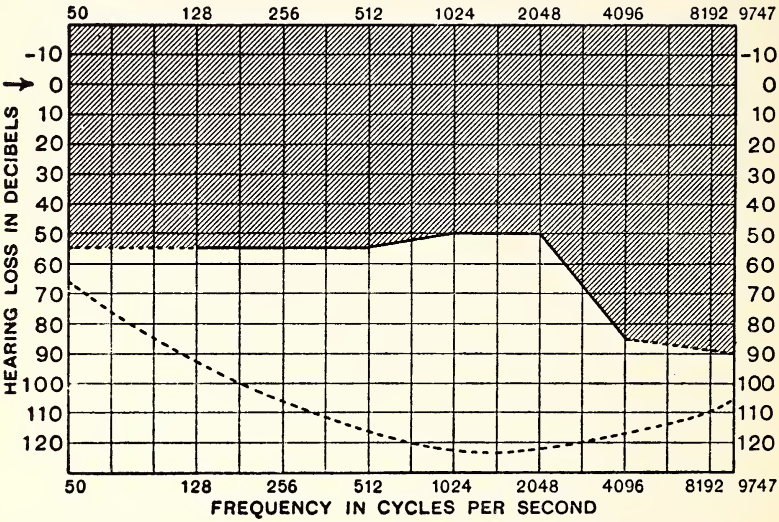


Diagram 36.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	55	55	65	65	50	80

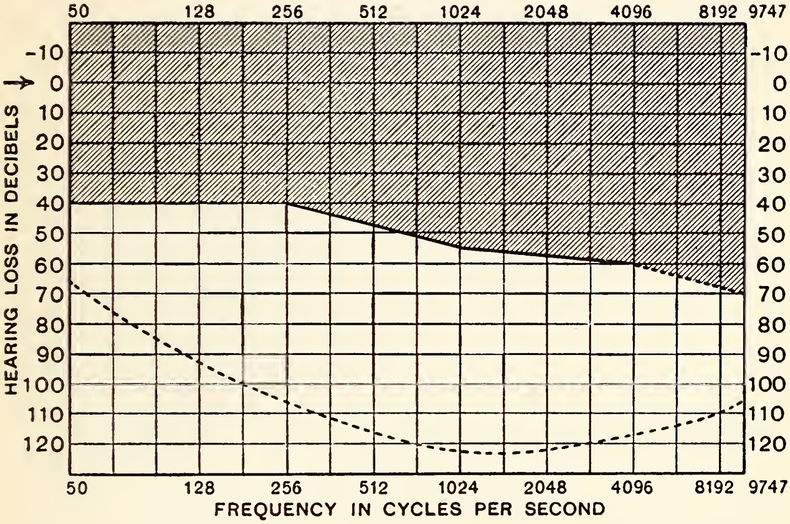


DIAGRAM 37.—Bone conduction, right ear.

Left ear	256	1024	4096
	40	55	60

Age : Over 60 years.

History.—Married woman living at home. Deafness increasing for six years. No treatment prescribed by otologist.

Tinnitus.—None reported.

Own speech.—Consonants not very distinct.

Notes.—Unable to take part in general conversation. Can follow slow distinct speech uttered close to ear if not much extraneous noise present. Cannot follow at theatre. Can hear some speakers on post office telephone and in broadcasts.

Benefit from aid.—The patient reported benefit because voices appeared louder when heard through the valve aid, and therefore called for less conscious effort in listening.

Patient No. 105.

		Vowels.	*Consonants.*
Intelligibility score, unaided	(at 3 feet)	$\frac{10}{10}$	$\frac{10}{10}$
,,	(at 6 feet)	$\frac{10}{10}$	$\frac{7}{10}$
valve aid		$\frac{10}{10}$	$\frac{7}{10}$

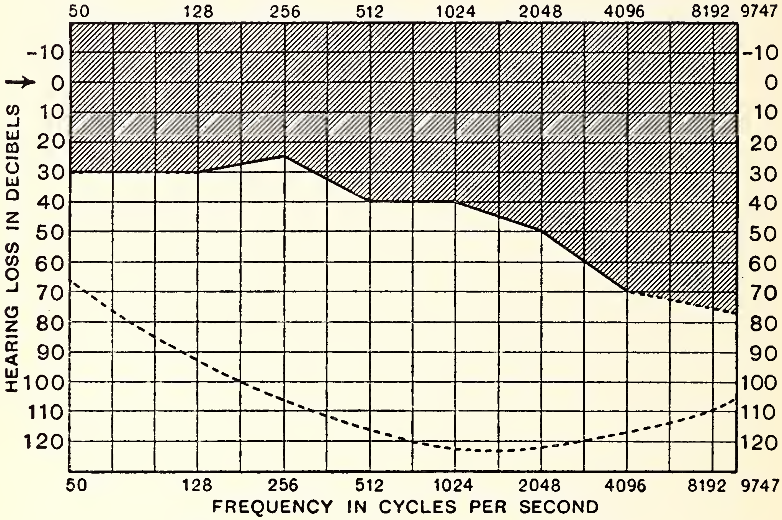


Diagram 38.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	40	35	40	40	50	65

Age : 80 years.

History.—Totally blind. Progressive deafness.

Own speech.—Normal.

Notes.—Member of boards and committees. Can follow conversation at 12 inches without any conscious difficulty, but says speakers " mumble nowadays " in committees.

Benefit from aid.—Mechanical aid makes consonants less distinct in *tête-à-tête* conversation. In boardroom, however, where distance from speakers is greater and where deafness makes much of what they say inaudible, the magnification of vowels and consonants gives valuable help, even though reproduction appears very imperfect.

Analysis of records of Grade I patients :

(1) Relatively slight loss of acuity, by air conduction, often causes difficulty in hearing speech in an auditorium and may be a handicap in conversation—see patient No. 102. Deafness to the extent of only 20 decibels is sometimes enough to cause some difficulty.

(2) Severe loss at the frequency of 4096 $\sim$ does not cause severe deafness for speech amongst adult patients, provided that acuity in other parts of the speech range is not greatly reduced. No Grade I patients showed severe loss at 2048 $\sim$.

(3) Bone-conduction measurements indicate that, in old-age deafness, a loss of 55 decibels is not incompatible with ability to follow *tête-à-tête* conversation at a short distance and in good acoustic conditions.

(4) Only a very few of the patients who have come for tests and advice have suffered from moderate or slight deafness. A radical change in the attitude of the general public towards the detection and early treatment of deafness seems to be needed.

Grade II.—Patients scoring 5 to 8 consonants in the Short Intelligibility Test when listening by unaided hearing.

Summary :

Patient.	Age.	Intelligibility Test.			
		Unaided.		Valve Aid.	
		Vowels.	Consonants.	Vowels.	Consonants.
A. *Patients helped by valve aid :*					
No. 106	35 years	10	7	10	9
„ 107	58 „	10	7	10	10
„ 108	45 „	7	6	10	10
„ 109	20 „	7	6	10	10
„ 110	24 „	7	6	10	10
„ 111	78 „	8	5	9	10
„ 112	16 „	6	5	9	10
„ 113	61 „	4	5	9	10
B. *Patients not helped by valve aid :*					
No. 114	77 years	10	8	10	6
„ 115	73 „	10	7	9	6
„ 116	13 „	7	5	7	6[1]

[1] See note on training, p. 240.

Sample audiograms and records :

Patient No. 106.

	Vowels.	*Consonants.*
Intelligibility score, unaided . .	$\frac{10}{10}$	$\frac{7}{10}$
valve aid . .	$\frac{10}{10}$	$\frac{9}{10}$

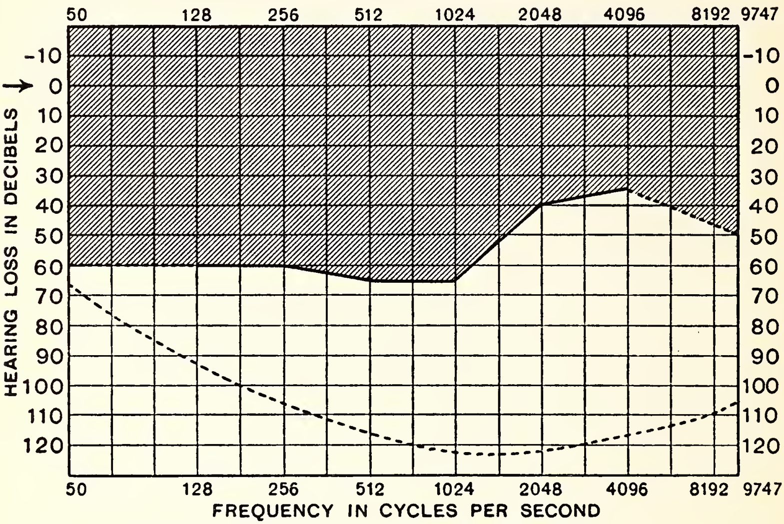


Diagram 39.—Audiogram air conduction, left ear.

Right ear	128	256	512	1024	2048	4096
	90	80	75	60	50	50

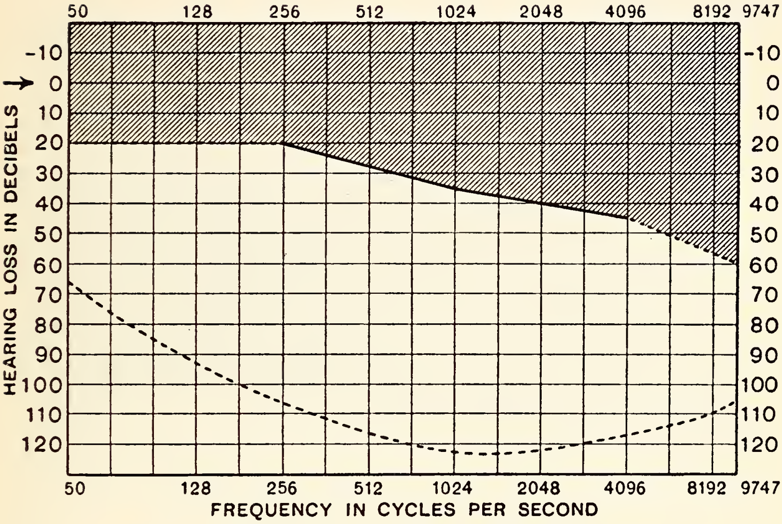


DIAGRAM 40.—Audiogram bone conduction, left ear.

Right ear	256	1024	4096
	10	15	45

Age: 35 years.

History.—Deafness observed over fifteen years. Diagnosis of catarrhal and sinus trouble.

Tinnitus.—Both sides. *Own speech.*—Normal.

Notes.—Increasing difficulty in following any speech with unaided ear. Said, " I sit back limp after a conversation." Has formed habit of watching speaker's face, though no lessons in lipreading.

Patient No. 108.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	$\frac{7}{10}$	$\frac{6}{10}$
valve aid	. .	$\frac{10}{10}$	$\frac{10}{10}$

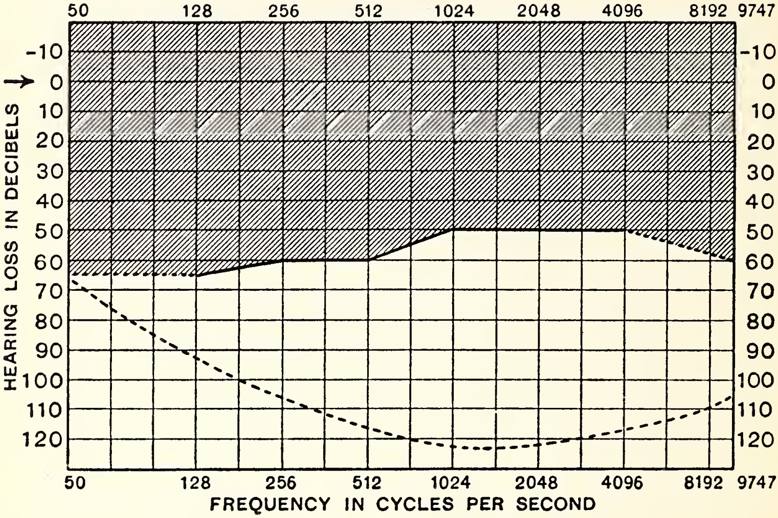


DIAGRAM 41.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	50	50	65	70	50	50

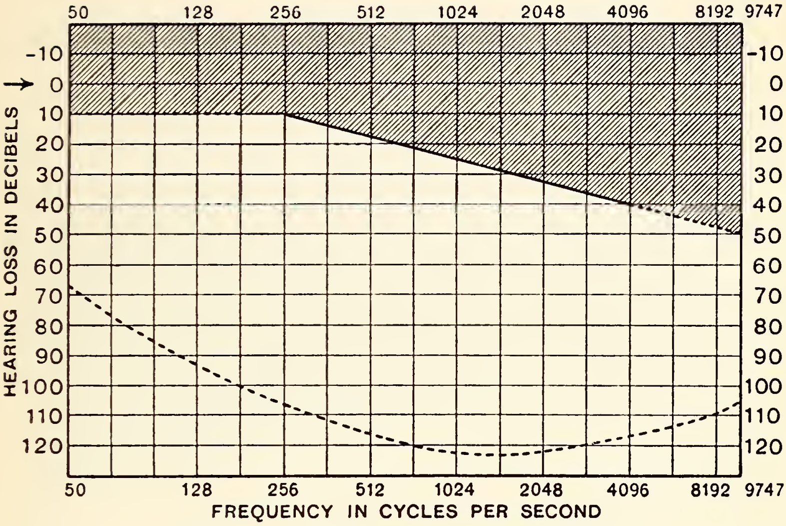


DIAGRAM 42.—Bone conduction, right ear.

Left ear	256	1024	4096
	10	25	30

Age : 45 years.

History.—Married woman living at home. States had influenza in childhood followed by drum perforations and progressive deafness.

Tinnitus.—Occasionally. *Own speech.*—Talks too quietly.

Notes.—Paracutic. Follows broadcast speech if very loud.

Patient No. 113.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	$\frac{4}{10}$	$\frac{5}{10}$
valve aid	. .	$\frac{9}{10}$	$\frac{10}{10}$

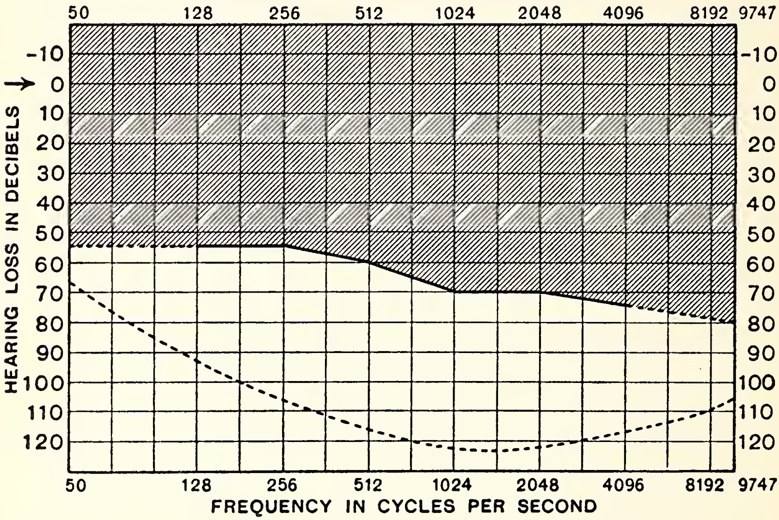


Diagram 43.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	90	75	75	80	80	80

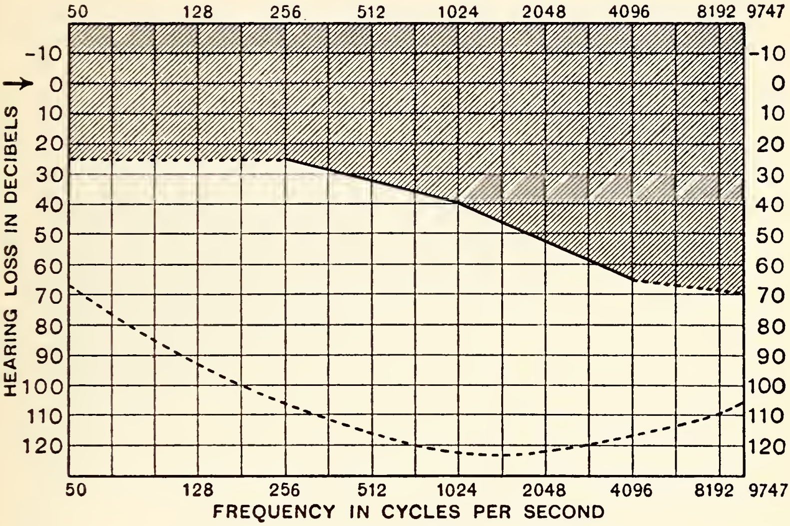


DIAGRAM 44.—Bone conduction, right ear.

Left ear	256	1024	4096
	25	35	70

Age : 61 years.

History.—Domestic servant, now unemployed. Deafness since childhood. Scarlet fever and measles.

Tinnitus.—Very severe.

Own speech.—Defective. Voice monotonous. Consonants imperfectly pronounced, especially "s".

Notes.—Paracutic. States that cannot follow broadcast speech.

Patient No. 115.

		Vowels.	Consonants.
Intelligibility score, unaided	. .	$\frac{10}{10}$	$\frac{8}{10}$
valve aid	. .	$\frac{10}{10}$	$\frac{6}{10}$

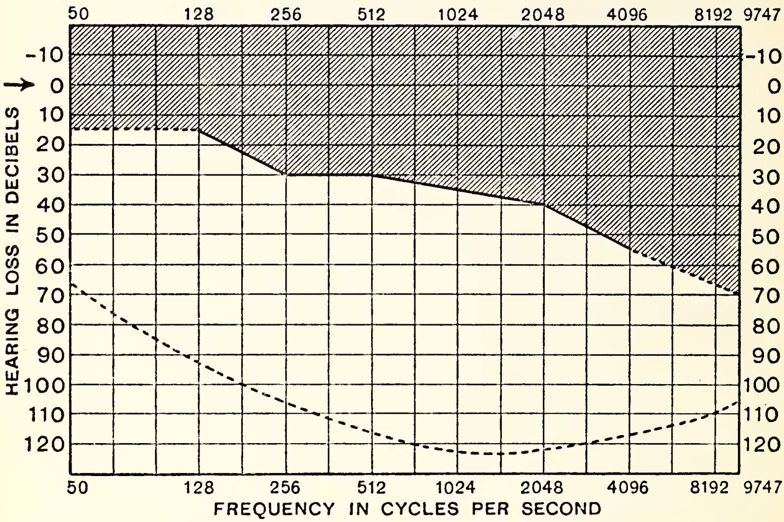


DIAGRAM 45.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	25	30	35	30	50	80

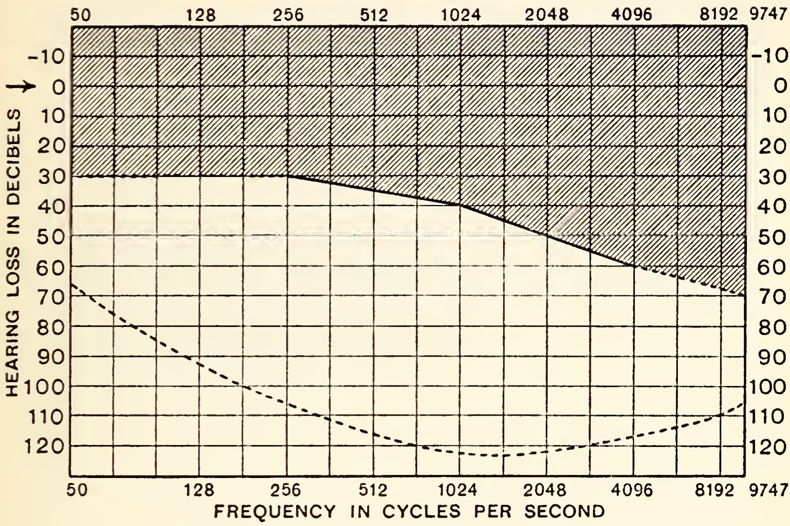


DIAGRAM 46.—Bone conduction, right ear.

Left ear	256	1024	4096
	30	40	60

Age : 77 years.

History.—Otologist diagnosed nasal catarrh. Double antrum operation several years previously.

Tinnitus.—None reported.

Own speech.—Normal.

Notes.—Cannot follow group conversation or plays at theatre. Could not endure parasitic noise of valve aid and therefore could not use it at other than weak intensities.

Patient No. 116.

	Vowels.	*Consonants.*
Intelligibility score, unaided . .	$\frac{7}{10}$	$\frac{5}{10}$
valve aid . .	$\frac{7}{10}$	$\frac{6}{10}$

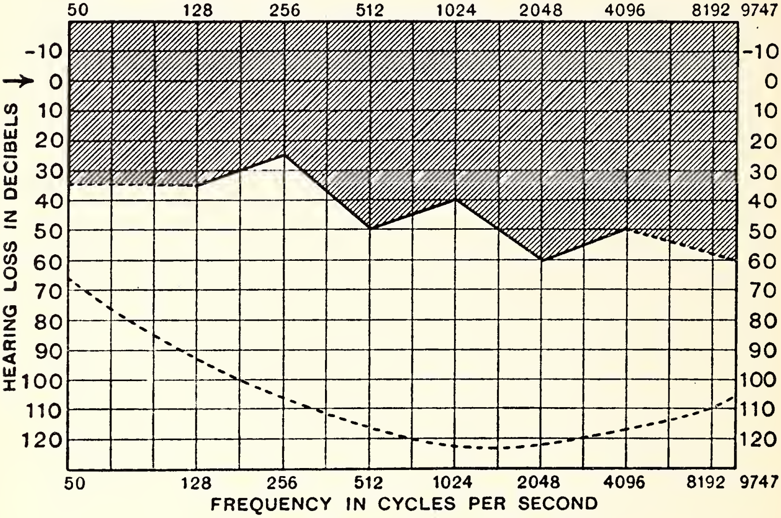


DIAGRAM 47.—Air conduction, left ear.

Right ear	128	256	512	1024	2048	4096
	35	40	40	40	70	65

Age : 13 years.

History.—Increasing deafness for about three or four years. Out-patient at a children's hospital.

Tinnitus.—None reported.

Own speech.—Defective. Consonants, especially " s," very imperfectly pronounced. Reported never to have been able to say " s " correctly.

Notes.—Says cannot catch what teacher says at school. In Standard VII. Would probably respond to combined speech and ear training with suitable classroom aid. (See Chapter XVII, p. 293.)

Analysis of records of Grade II patients :

(1) Grade II patients usually have less hearing for pure tones than those belonging to Grade I. This, however, is not an invariable rule.

Patient No. 115 (Grade II) is clearly less deaf than Patient No. 105 (Grade I). Their ages are similar, 77 years and 80 years. No. 115 has undergone operative treatment. No. 105, on the other hand, is totally blind. It appears very probable that No. 105 hears speech better as the result of greater mental alertness and greater capacity for sustained attention. The nature of his activities suggest that he is a man of unusual powers.

(2) No. 113 is the most seriously deaf Grade II patient. The results of tests of the better ear of the other 10 patients included only a few readings of 70 decibels loss and those are all for isolated frequencies, not for two adjacent frequencies. For listening to speech with the unaided ear, Patient No. 113 must rely almost exclusively on the better ear, the right, and especially on hearing sound of pitch below 1024∼.

(3) No blind patients were found to be classifiable as Grade II.

(4) There were no hearing curves of the kind which slope very steeply from left to right and show severe high-frequency deafness.

Grade III.—Patients scoring fewer than 5 consonants but able to recognise some speech sounds by unaided listening in the Short Intelligibility Test.

Sample audiograms and records :

Patient No. 117.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	$\frac{7}{10}$	$\frac{4}{10}$
valve aid	. .	$\frac{10}{10}$	$\frac{10}{10}$

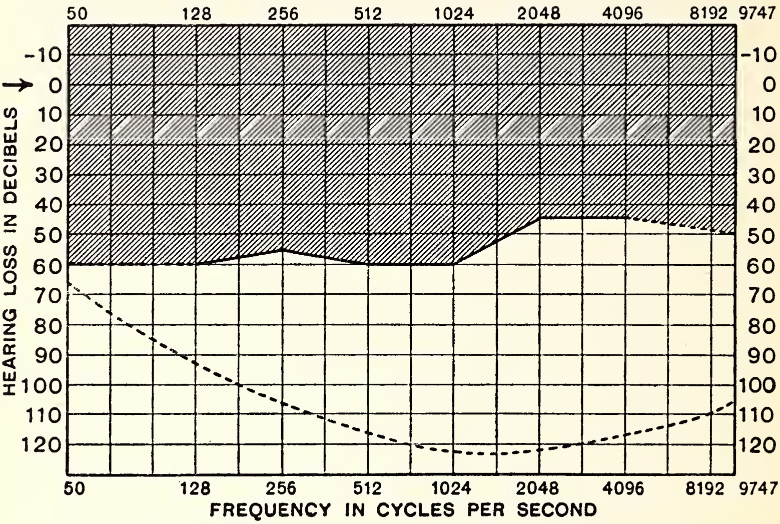


Diagram 48.—Air conduction, left ear.

Right ear	128	256	512	1024	2048	4096
	55	60	70	70	45	55

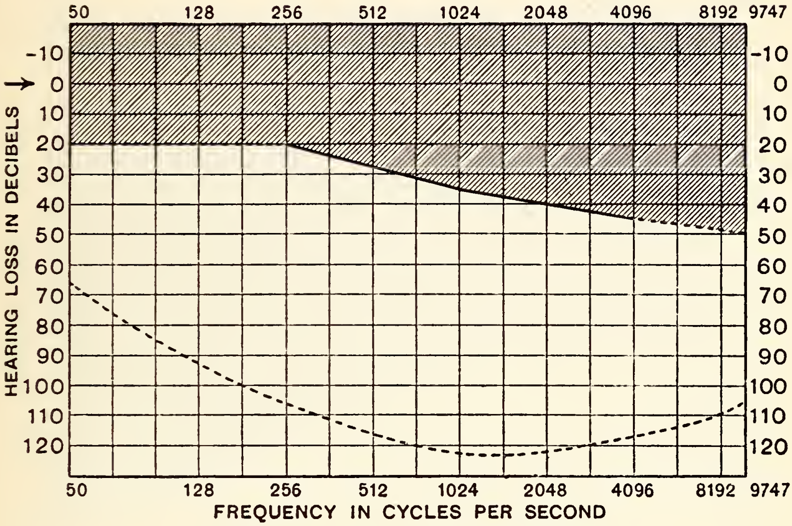


DIAGRAM 49.—Bone conduction, left ear.

Right ear	256	1024	4096
	10	35	45

Age : 45 years.
History.—Deaf for eight years. Diagnosis—dry catarrh.
Tinnitus.—Yes.
Own speech.—Too quiet to be easily heard. No defects in pronunciation.
Notes.—Paracutic. Can follow broadcast speech when very loud.

Patient No. 125.

	Vowels.	*Consonants.*
Intelligibility score, unaided . .	$\frac{7}{10}$	$\frac{0}{10}$
valve aid . .	$\frac{10}{10}$	$\frac{9}{10}$

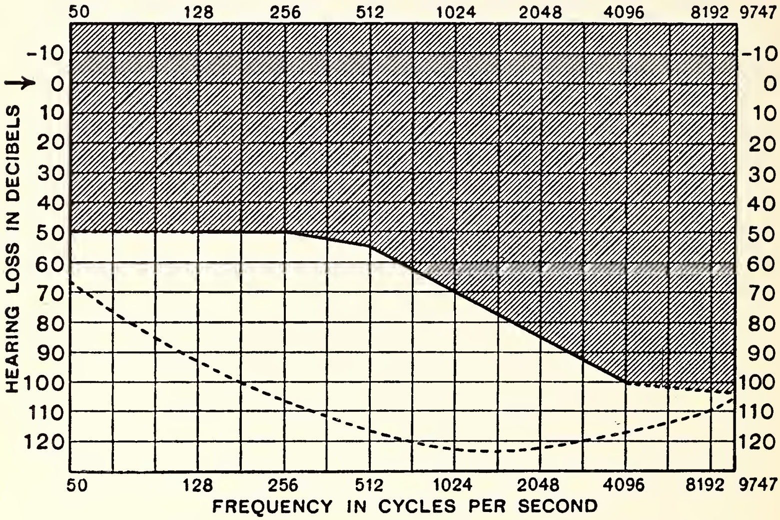


DIAGRAM 50.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	100	80	90	95	100	100

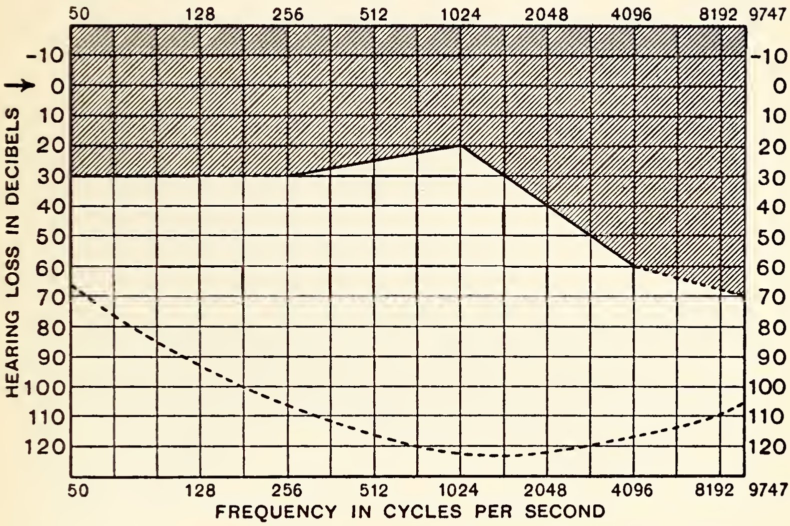


DIAGRAM 51.—Bone conduction, right ear.

Left ear	256	1024	4096
	25	40	60

Age : 50 years.

History.—Blind. Scarlet fever at five years.

Tinnitus.—Yes, " buzzing."

Own speech.—Too quiet to be easily heard.

Notes.—Cannot hear broadcast speech distinctly, but " can manage near to."

Patient No. 129.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	$\frac{3}{10}$	$\frac{0}{10}$
valve aid	. .	$\frac{9}{10}$	$\frac{9}{10}$

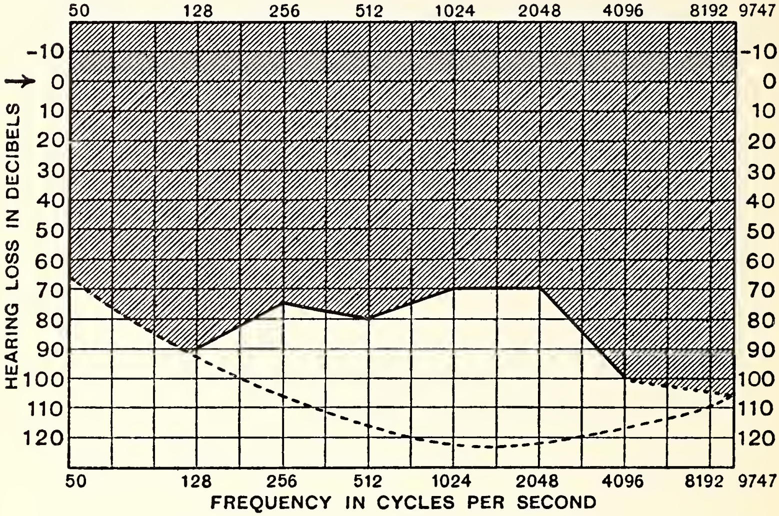


DIAGRAM 52.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	65	75	80	75	90	100

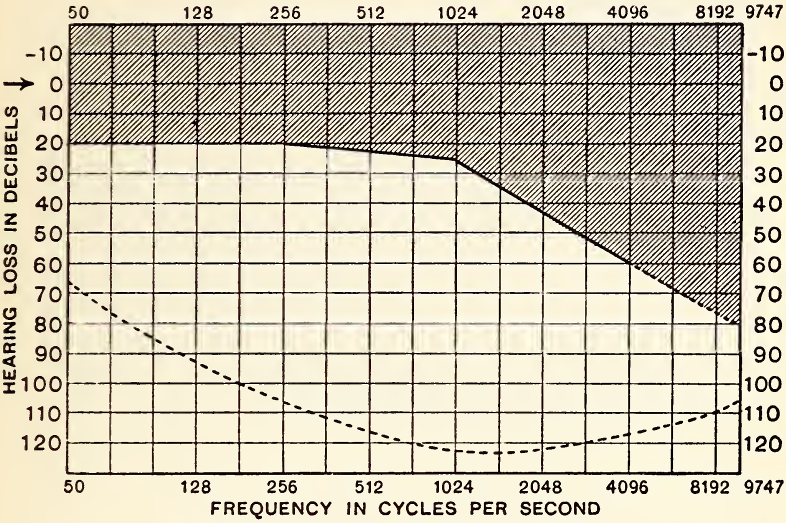


DIAGRAM 53.—Bone conduction, right ear.

Left ear	256	1024	4096
	15	30	60

Age : 56 years.

History.—Engineer. Increasing deafness for twenty years.

Own speech.—Normal.

Tinnitus.—Formerly, but now ceased.

Notes.—Paracutic. Enjoys listening to broadcast programmes, but feels that he hears high-pitched sounds better than low. Probable explanation is that he hears the loudest components of speech and music, which occur in the middle of the frequency range, better than the weak lower tone components which characterise bass voices and bass instrumental sound.

Patient No. 136.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	$\frac{10}{10}$	$\frac{3}{10}$
valve aid	. .	$\frac{10}{10}$	$\frac{6}{10}$

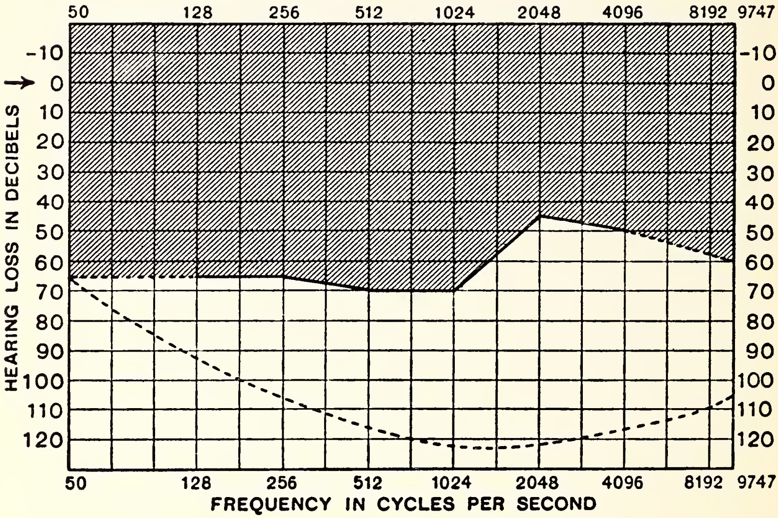


DIAGRAM 54.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	70	70	65	65	40	50

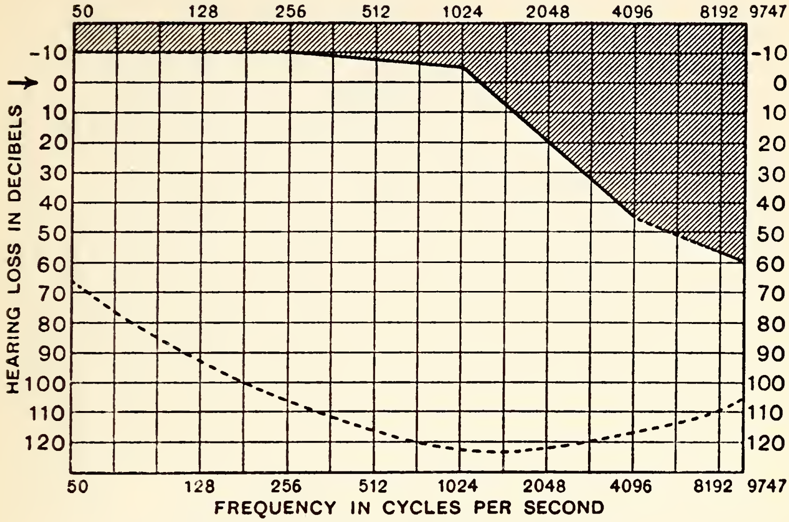


DIAGRAM 55.—Bone conduction, right ear.

Left ear	256	1024	4096
	10	0	60

Age : 24 years.

History.—Measles at eleven years. Tonsils and adenoids removed at thirteen years. No family history of deafness.

Otologist's report.—" On inspection the ears are dry, the drum membranes are almost normal in appearance, but are somewhat atrophic and give the impression of a dry middle ear, in other words, a so-called chronic dry catarrhal otitis media is present in both ears. . . . The nose looked clean and healthy, the mouth, fauces, and post-nasal space all appeared clean and healthy. I did not try catheter inflation because I found that when she performed Valsalvas' experiment, I could see the drum membrane and ossicles move in both ears. On testing the hearing, immediately after inflation in this way, there was no appreciable change. . . . I formed the opinion that she is suffering from a form of conductive deafness . . . probably catarrhal in origin, and a legacy from measles. The prognosis is bad. She has already had the deafness for thirteen or fourteen years, and it is already severe. . . . I would strongly advocate that she learn lipreading, and she will also have to consider the use of some form of aid. . . ."

Own speech.—Normal.

Summary :

Patient.	Age.	Intelligibility Test. Unaided. Vowels.	Intelligibility Test. Unaided. Consonants.	Intelligibility Test. Valve Aid. Vowels.	Intelligibility Test. Valve Aid. Consonants.
A. *Patients helped by valve aid :*					
No. 117	45 years	7	4	10	10
„ 118	47 „	6	4	10	9
„ 119	not stated	6	3	10	9
„ 120	20 years	6	3	10	10 [1]
„ 121	41 „	5	3	10	9
„ 122	42 „	5	2	10	10
„ 123	40 „	5	1	10	9
„ 124	56 „	3	1	10	9
„ 125	50 „	7	0	10	9
„ 126	50 „	4	0	10	9
„ 127	41 „	3	0	9	10
„ 128	68 „	3	0	10	9
„ 129	56 „	3	0	9	9
„ 130	66 „	2	0	9	9
„ 131	44 „	2	0	10	10
„ 132	77 „	10	4	9	7
„ 133	11 „	8	4	10	7
„ 134	17 „	8	4	9	7 [1]
„ 135	70 „	6	4	9	5
„ 136	24 „	10	3	10	6
„ 137	not stated	4	3	10	7
„ 138	70 years	4	3	10	6
„ 139	35 „	9	2	10	6
„ 140	50 „	7	2	9	8
„ 141	19 „	5	2	10	8 [1]
„ 142	15 „	5	1	8	8 [1]
„ 143	22 „	6	1	10	5 [1]
„ 144	55 „	5	1	10	8
„ 145	32 „	6	0	10	8
„ 146	74 „	4	0	10	8
„ 147	44 „	4	0	10	6
B. *Patient not helped by valve aid :*					
No. 148	13 years	3	0	needs training.[1]	

[1] See note on training, p. 240.

Analysis of records of Grade III patients :

(1) There were 14 instances, amongst 32 patients in this grade, of 70 or more decibels loss of hearing by air conduction, in the better ear, at more than one of the frequencies tested.

(2) Severe high-frequency deafness, as illustrated in the case of patient No. 125, was found in four instances.

(3) For air-conduction results the hearing curves of Grade III show, in general, appreciably greater loss than those of Grade II or Grade I patients.

(4) The bone-conduction curves are not worse for Grade III patients than for those in Grades I or II. Patient No. 136 is of special interest as having super-normal hearing at 256~ and 1024~ when tested with the bone-conduction receiver.

(5) There were two Grade III blind-deaf patients.

Grade IV.—Patients unable to recognise any vowels or consonants, by unaided listening, in the Short Intelligibility Test.

Sample audiograms and records :

Patient No. 156.

	Vowels.	*Consonants.*
Intelligibility score, unaided . .	No speech heard	
valve aid . .	$\frac{10}{10}$	$\frac{9}{10}$

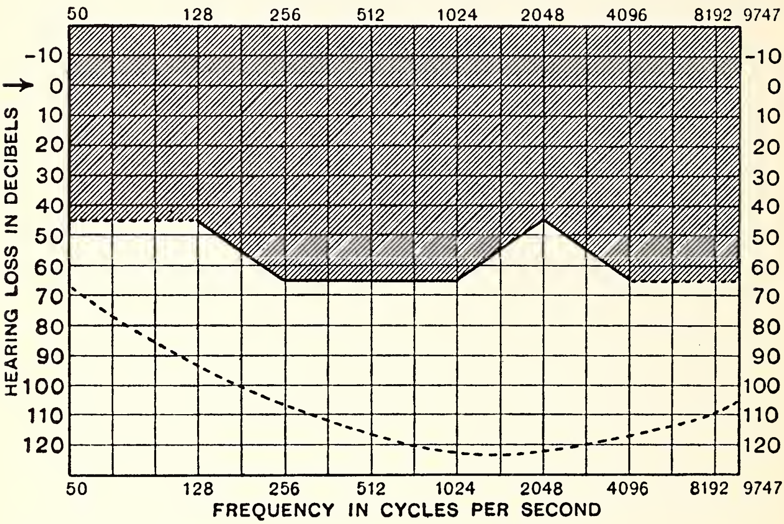


Diagram 56.—Air conduction, left ear.

Right ear	128	256	512	1024	2048	4096
	55	70	75	65	55	95

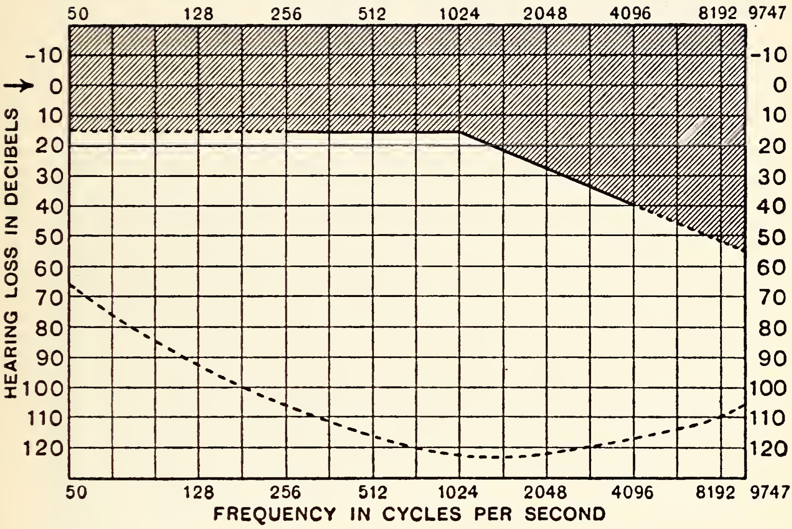


DIAGRAM 57.—Bone conduction, left ear.

Right ear	256	1024	4096
	15	20	40

Age : 51 years.

History.—Married woman living at home. Deafness first noticed at 18 years. Two middle ear operations.

Tinnitus.—Yes.

Own speech.—Normal.

Notes.—Paracutic. Sometimes able to follow broadcast speech, " according to speaker's voice."

Patient No. 164.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	No speech heard	
valve aid	. .	$\frac{10}{10}$	$\frac{8}{10}$

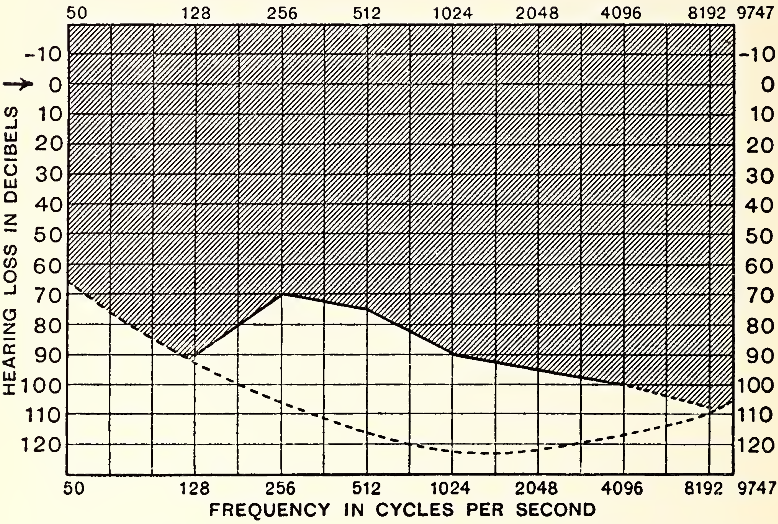


Diagram 58.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	90	65	85	95	95	100

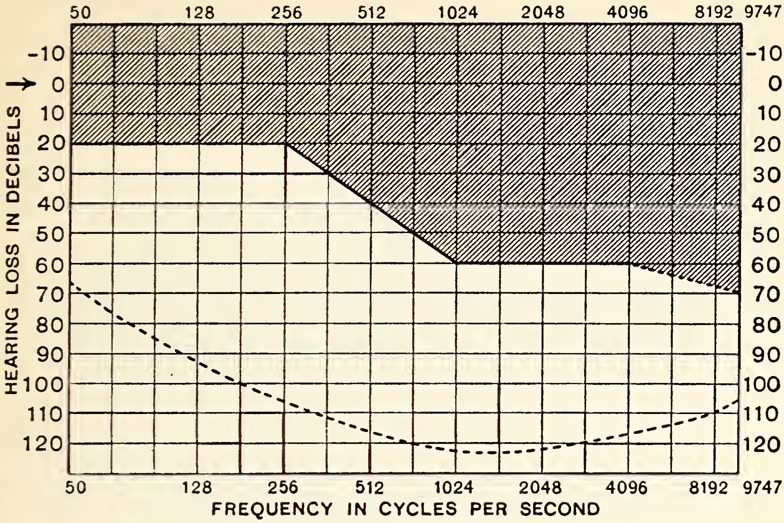


DIAGRAM 59.—Bone conduction, right ear.

Left ear	256	1024	4096
	15	60	60

Age : 27 years.

Otologist's report—"This patient is really very severely deaf. She tells me it has been growing gradually for the past two years, but I wonder if it was not present slightly before this. When the deafness was first noticed she was suffering from frequently running nasal colds. It was then noticed that her hair was coming off. She visited a hairdresser, who advised treatment. This treatment consisted of wetting the hair night and morning. This seemed to increase the susceptibility to colds and it was then that the deafness became really noticeable. The treatment for the hair was stopped, but unfortunately the deafness progressed. The father's mother was deaf, the mother's father was slightly deaf and one nephew is also slightly deaf. . . . She has never had any discharge from the ears, but she has much catarrhal discharge coming down from the back of the nose into the throat. . . . She suffered chicken-pox and measles with pneumonia in childhood, but has had no serious illnesses. On examination the ears are dry, both drum membranes show chronic catarrhal discharge of the adhesive type. Atrophic changes have now taken place, so that there is a dry middle ear on both sides. The nose shows the septum slightly deviated towards the left, but the mucosa is healthy. There is some post-nasal catarrh and a little chronic tonsillitis. . . . She has no useful hearing for ordinary purposes."

Tinnitus.—Yes, twelve months ago, but ceased since treatment.

Own speech.—Normal.

Notes.—Not paracutic. Cannot follow broadcast speech.

Patient No. 169.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	No speech heard	
valve aid	. .	$\frac{8}{10}$	$\frac{7}{10}$

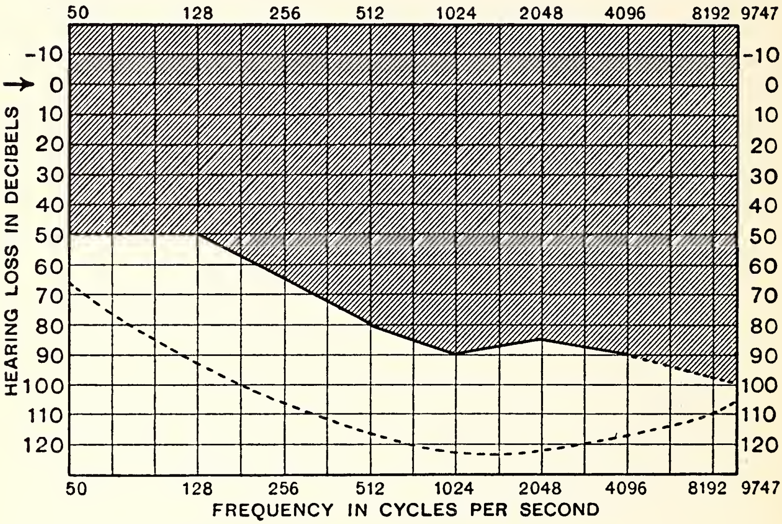


Diagram 60.—Air conduction, right ear.

Left ear	128	256	512	1024	2048	4096
	55	60	75	95	95	90

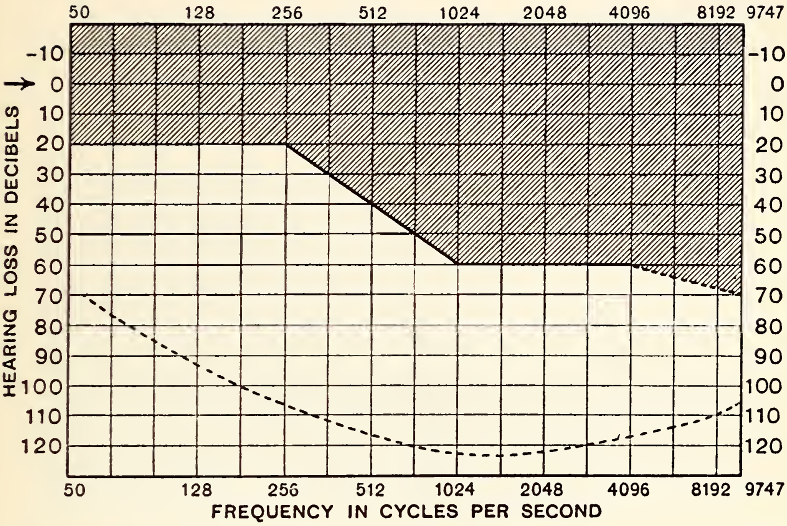


DIAGRAM 61.—Bone conduction, right ear.

Left ear	256	1024	4096
	15	60	60

Age : 43 years.

History.—Married woman living at home. Deafness first noticed about sixteen years previously.

Otologist's report.—" On examination, I find both ears dry, both drum membranes show catarrhal retraction, and atrophic changes. She also has some chronic tonsillitis, and a nasal septum deflected to the left. . . . This is evidently a case of old chronic conductive deafness."

Tinnitus.—No.

Own speech.—Normal.

Notes.—Paracutic. Can follow " some part " of wireless broadcast programmes.

Patient No. 175.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	No speech heard	
valve aid	. .	$\frac{8}{10}$	$\frac{6}{10}$

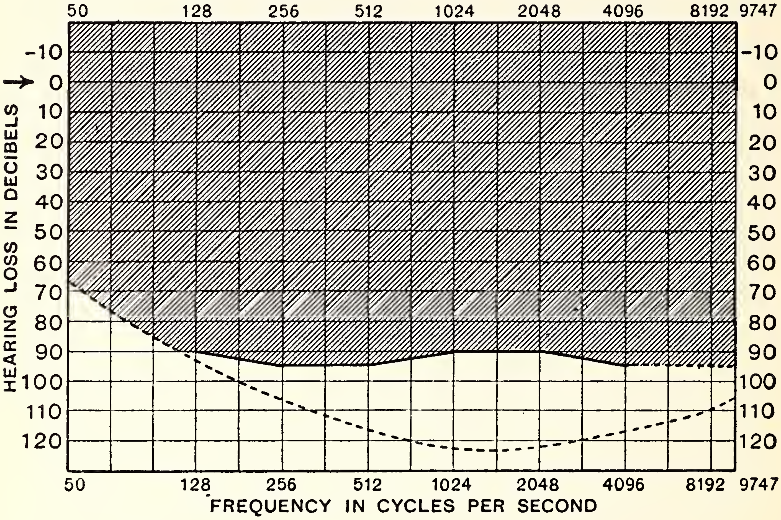


Diagram 62.—Air conduction, right ear.

Left ear : no sound heard.

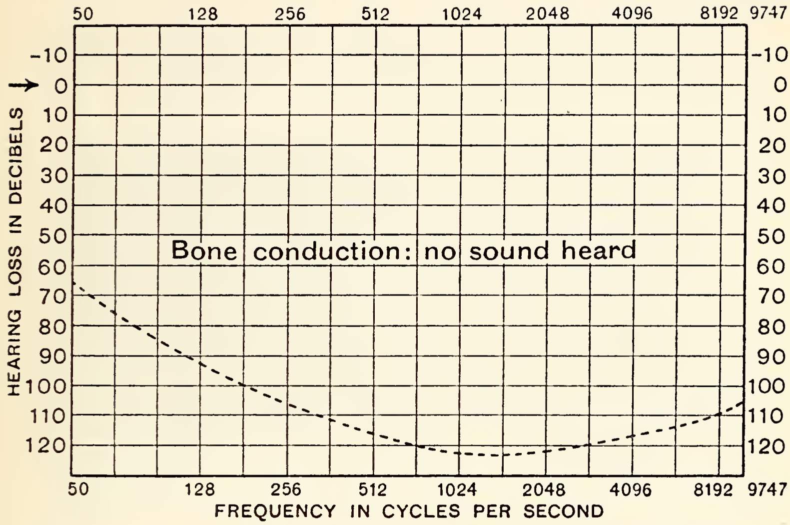


Diagram 63.—Bone conduction, no sound heard.

Left ear : no sound heard.

Age : 47 years.
History.—Blind. Deaf since diphtheria at twelve years.
Tinnitus.—No.
Own speech.—Defective " s " and " t."
Notes.—Not paracutic. Cannot follow broadcast speech.

Patient No. 185.

		Vowels.	*Consonants.*
Intelligibility score, unaided	. .	No speech heard	
valve aid	. .	$\frac{10}{10}$	$\frac{9}{10}$ [1]

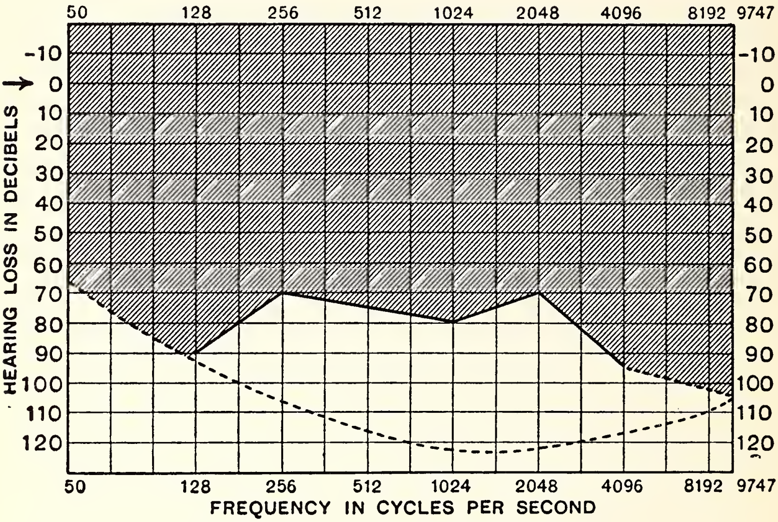


DIAGRAM 64.—Air conduction, right ear.

Left ear : no sound heard.

[1] With speaking-tube.

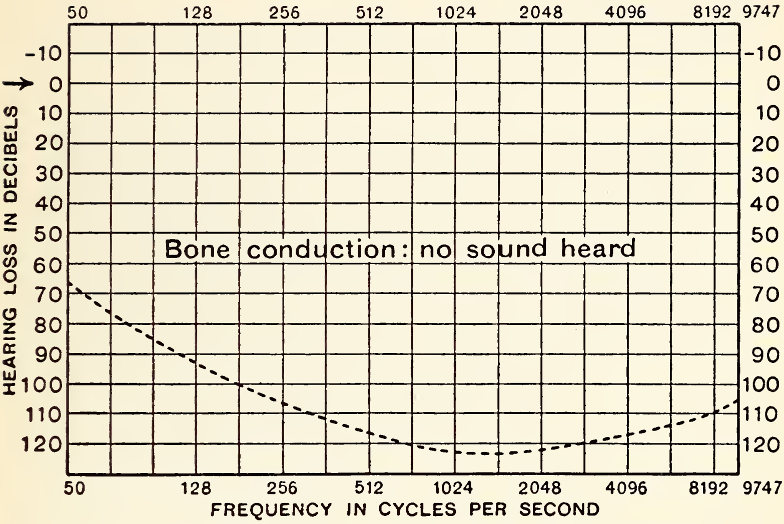


DIAGRAM 65.—Bone conduction, right ear. No sound heard.

Left ear : no sound heard.

Age : 34 years.

History.—Blind. Reports deafness first noticed seven years ago and worse after influenza two years ago.

Tinnitus.—Yes.

Own speech.—Toneless, monotonous voice.

Notes.—Not paracutic. Cannot follow wireless programmes. No electrical aid gives any help.

Patient No. 189.

Intelligibility score, no speech heard, unaided or with any form of hearing-aid.

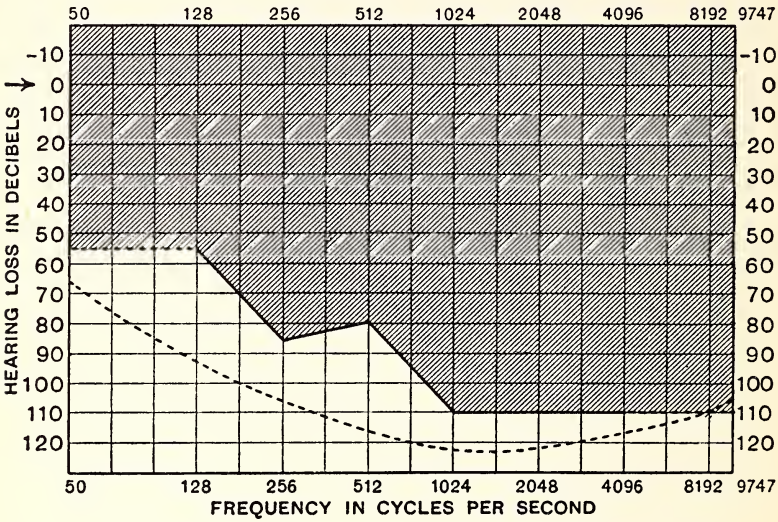


Diagram 66.—Air conduction, left ear.

Right ear	128	256	512	1024	2048	4096
	70	90	90	110	110	110

No bone-conduction test.

Age : 61 years.
History.—Blind. Deaf for twenty-six years.
Tinnitus.—Yes.
Own speech.—Talks Welsh in whispered voice.
Notes.—Reported that heard a " noise " through aid, but could not interpret it as speech. Can be helped only by finger-spelling.

Summary :

Patient.	Age.	Intelligibility Score.			
		Unaided.		Valve Aid.	
		Vowels.	Consonants.	Vowels.	Consonants.
(a) Patients helped by valve aid :					
No. 149	58 years	No sound heard		10	10
,, 150	62 ,,	,,	,,	10	10
,, 151	62 ,,	,,	,,	10	10
,, 152	21 ,,	,,	,,	9	10
,, 153	66 ,,	,,	,,	8	10
,, 154	51 ,,	,,	,,	10	9
,, 155	67 ,,	,,	,,	10	9
,, 156	51 ,,	,,	,,	10	9
,, 157	58 ,,	,,	,,	10	9
,, 158	45 ,,	,,	,,	10	9
,, 159	17 ,,	,,	,,	9	9 [1]
,, 160	24 ,,	,,	,,	10	8
,, 161	50 ,,	No speech heard		10	8
,, 162	35 ,,	,,	,,	10	8
,, 163	47 ,,	,,	,,	10	8
,, 164	27 ,,	,,	,,	10	8
,, 165	55 ,,	,,	,,	9	8
,, 166	72 ,,	,,	,,	10	7
,, 167	8 ,,	,,	,,	10	7 [1]
,, 168	56 ,,	,,	,,	9	7
,, 169	43 ,,	,,	,,	8	7
,, 170	70 ,,	,,	,,	8	7
,, 171	43 ,,	,,	,,	8	7
,, 172	53 ,,	,,	,,	7	7
,, 173	47 ,,	,,	,,	9	6
,, 174	58 ,,	,,	,,	9	6
,, 175	47 ,,	,,	,,	8	6
,, 176	62 ,,	,,	,,	8	6
,, 177	62 ,,	,,	,,	5	5
(b) Patients obtaining useful but limited help from a valve aid :					
No. 178	58 years	No speech heard		9	8 [2]
,, 179	65 ,,	,,	,,	9	4
,, 180	66 ,,	,,	,,	9	4 [3]
,, 181	7 ,,	,,	,,	6	4 [3]
,, 182	58 ,,	,,	,,	8	3 [1]
,, 183	16 ,,	,,	,,	6	3 [3]
,, 184	41 ,,	,,	,,	6	2
(c) Patients helped by speaking-tube only :					
No. 185	34 years	No sound heard		10	9 [4]
,, 186	not stated	,,	,,	8	5 [4]
,, 187	61 years	,,	,,	9	9 [4]
(d) Patients totally deaf to speech :					
No. 188	66 years	No sound heard		0	0
,, 189	61 ,,	,,	,,	0	0
,, 190	13 ,,	,,	,,	0	0 [1]

[See page 196 for footnotes.

Analysis of records of Grade IV patients :

(1) Every Grade IV patient was found to have a hearing loss of 70 or more decibels, in the air-conduction test of the better ear, at two or more of the frequencies tested.

(2) There were seven instances of severe binaural high-frequency deafness.

(3) Hearing curves, made by air-conduction test, do not show whether or not a patient can be helped by means of a hearing-aid, except in an extreme instance, e.g. in the case of patient No. 189, where there is virtually total deafness in the better ear for sound above 512∼, with severe deafness from 256∼ to 512∼.

(4) The fact that patients, such as Nos. 186 and 188, although not totally deaf, could hear no sound when tested with the bone-conduction receiver, seems to indicate that equipment is needed which will enable bone-conduction tests to be made at much larger intensities than are available at present.

(5) Among 13 patients, who could be given only limited help by means of an aid, or who could not be helped at all, 7 were blind and deaf and 3 were born severely (previously presumed totally) deaf.

Conclusions.

A. Hearing curves and capacity to hear speech with the unaided ear.

The hearing loss for pure tones found among deaf patients, classified according to their scores in the Short Intelligibility Test when listening without any form of aid, may be expressed approximately as follows :

Grade I.—A maximum hearing loss of 20 decibels is sometimes enough to cause difficulty in following speech, especially in an auditorium. Amongst adult patients severe deafness at 4096∼ (unaccompanied by severe loss at lower frequencies) and a maximum air-conduction loss of 55-65 decibels, and bone-

[1] See note on training, p. 241.

[2] Good results only with slow speech, uttered not more than 18 inches from the microphone.

[3] If slow speech and uttered 12 inches from the microphone ; see also note on training, p. 241.

[4] Result with speaking-tube.

conduction loss of 55 decibels, at 1024~, are not incompatible with ability to follow *tête-à-tête* conversation at 36 inches in a quiet place. Similar deafness in childhood or adolescence, however (see Chapters XVI and XVII), is a far more serious handicap.

Grade II.—Patients in this grade usually, but not invariably, show greater deafness to pure tones than those in Grade I. Experience, intelligence and temperament are probably important factors in determining hearing for speech. Hearing loss of 70 or more decibels is not common amongst Grade II patients, and when found it is almost invariably confined to one frequency.

Severe high-frequency deafness (e.g. patient No. 125) is incompatible with Grade I or II capacity to hear.

Grade III.—Hearing loss of 70 or more decibels at more than one frequency was found in the better ears of nearly half the Grade III patients. There were four instances of severe high-frequency deafness (e.g. patient No. 125).

Grade IV.—Every patient in this grade had a hearing loss of 70 or more decibels, in the better ear, at two or more of the frequencies tested. There were seven instances of severe high-frequency deafness.

B. Inability to benefit from the use of an aid.

This can be determined from inspection of hearing curves in a few cases, e.g. in that of patient No. 189, where useful hearing is found only below 256~.

The principal factors which prevent deaf patients from hearing conversation more clearly with the help of a good valve aid have proved to be :

(i) inability amongst elderly patients (Nos. 105, 114, 115) to endure the loudness of speech when amplified sufficiently to enable them to hear the important components of higher pitch, which carry the consonants. Often associated with this there is mental discomfort caused by parasitic or extraneous noise ;

(ii) onset of deafness in childhood, or deafness from birth, preventing experience in hearing speech, the formation of habits of response to sound (patients Nos. 116, 148 and 190). Patients Nos. 134, 141, 142, 143, 159 and 167 are pupils whose ability to follow

speech by ear has either mainly or in part been acquired by education through lipreading and a specially designed form of hearing-aid. Patients Nos. 181 and 183 were diagnosed totally deaf before being trained in this way ;

(iii) very severe deafness (patients Nos. 185, 186, 187, 188, 189). The speaking-tube helps when a valve aid fails in these cases, probably because it reproduces speech with less distortion.

C. Blind deaf patients.

Fourteen were given the Short Intelligibility Test and the unaided results were :

Grade	I.	1 patient,
,,	III.	1 ,,
,,	IV.	12 patients.

The hearing curves of the 12 Grade IV patients showed severe deafness to pure tones. Nevertheless 7 out of the 12, together with the Grade III patient, could be given marked help by means of a valve aid.

D. Age.

Grade I patients tend to fall into two groups, the youthful and the elderly. The nearest approach to a homogeneous age-group is found amongst those Grade III patients who obtain a Grade I score with the help of an aid. Here there is a preponderance of individuals in middle life, often with a history of long-established progressive deafness.

E. Tinnitus (head-noises) reported by

0	amongst	5	Grade I	patients.
7	,,	11	,, II	,,
19	,,	32	,, III	,,
31	,,	42	,, IV	,,

This gives a total of 57 patients or 63 per cent. Tinnitus is thus more frequently reported in proportion to the severity of the deafness. It should be noted, however, that the more severely deaf the patient, the more cut off is he from the sounds of the external world ; if therefore he hears any sounds originating within his own body or auditory mechanism they appear

as if he were in a sound-proof room; they may seem loud disproportionately to their actual strength as a form of stimulation.

F. Defects of speech.

Defects of voice management or pronunciation were noted among

0	amongst	5	Grade	I	patients.
5	"	11	"	II	"
13	"	32	"	III	"
19	"	42	"	IV	"

This gives a total of 37 or 41 per cent.[1] The consonants most frequently defective were "s," "t," and "sh," but there were also instances of mispronunciation of vowels. Too loud or too quiet a voice was used by a number of patients. The defects of speech found amongst deaf children were even more serious, in proportion to the degree of deafness, than those found amongst adults.

G. Bone-conduction tests.

The electrical equipment available, though much superior to tuning-forks, is not capable of reproducing sound at large enough intensities for testing some deaf patients.

Note on adaptation of hearing aids to individual needs.

This problem falls under the two heads of loudness and distortion which have already been approached in an earlier chapter.

(*a*) *Distortion.*

Experiments were described in the *Medical Research Council Report*, "The Use of Hearing Aids," in which patients suffering from different forms of deafness—middle-ear, high-frequency and old-age—were tested intensively, over a period of time, with moving-coil, crystal and ordinary moving-iron telephones respectively. The effect of using these telephones, connected to the valve amplifier through suitable output transformers, was to modify the reproduction of high- and low-pitched components in speech.

[1] This percentage is lower than that given in Chapter IV, which refers to severely deaf patients only.

The results of a long series of experiments, however, seemed to show that, with the best technical equipment available at the present time, it is doubtful whether it is yet possible to modify the design of aids to suit individual patients.

The four principal types of telephone used were :

(*a*) a moving-coil telephone No. 1, giving relatively uniform amplification at all speech frequencies ;
(*b*) a moving-coil telephone No. 2, giving less amplification at low than at high frequencies ;
(*c*) a crystal telephone, giving relatively uniform amplification at all speech frequencies ;
(*d*) a moving-iron telephone, giving less amplification at high than at low frequencies.

The results of the experiments with 8 patients were that :

2 patients scored highest intelligibility with the moving-coil telephones,
4 patients scored highest intelligibility with the crystal telephones,
2 patients scored equally well with moving-coil or with crystal telephones.

It is noticeable that no patient heard best with the moving-iron telephone. Only 1 patient heard best with the moving-coil telephone No. 2. She was a subject aged 67 years with a long history of progressive deafness. Another patient with a similar history heard better with the crystal telephone. A severely high-frequency deaf patient, who might have been expected to benefit by greater amplification of high than low notes, scored highest with the crystal telephone and not with moving-coil telephone No. 2.

Littler[1] writes : " It is extremely difficult to get effective amplication of the region 3000-8000 even with the best hearing-aids at present in use. There is need for improvement in the manner of applying the sounds to the ear, as it seems that the present design of ear-piece causes a serious loss in the upper frequencies."

[1] Littler, T. S., 1936, " Hearing Aids for the Deaf," *Journal of Scientific Instruments*, 13, 5, pp. 144-55.

(*b*) *Loudness.*

To obtain the maximum amount of help from a hearing-aid it is usually necessary that it should be able to reproduce speech as accurately as possible at large intensities.

In part this is probably due to the difficulty mentioned in the paragraph immediately above—namely, that of obtaining effective amplification of the higher pitched sounds in the speech range.

Boys and girls born deaf and patients who have long been accustomed, through deafness, to weak sensations of sound are often nervous about listening to loud sounds when they first try an aid. When such patients persist in regular use of a good aid, which gives them efficient help, their fears are dispelled and, in some cases, they have often been known to ask for more amplification.

Deaf patients usually hear speech best at an intensity 90 to 110 decibels above the normal threshold of hearing.

This corresponds to the loudness of a busy machine shop, of a loud motor horn, or of a busy typing room.[1]

The following experimental results are quoted from the *Medical Research Council Report* already mentioned :

Intelligibility of Vowels and Consonants heard through a Valve Hearing-aid at Different Loudness Levels.

(*Subject's score per cent. at each level.*)

Intensity level in decibels above normal threshold of audibility.	70		90		100		110	
Subject.	Vowels.	Consonants.	Vowels.	Consonants.	Vowels.	Consonants.	Vowels.	Consonants.
D. 2 .	no speech heard		95	55	100	75	100	90
E. 3 .	45	no test	100	80	100	95	100	95
G. 3 .	unintelligible		60	25	62	30	discomfort	

When the formula given by Davies [2] is applied to these figures the intelligibility of speech, as a whole, to these patients, is shown to be :

[1] See Chapter VIII. [2] See p. 42.

Percentage Intelligibility at Different Loudness Levels.

Intensity level in decibels above normal threshold of audibility.	70	90	100	100
Subject.	Intelligibility of speech per cent.			
D. 2 .	no speech heard	27·5	56	81
E. 3 .	no test	64	90	90
G. 3 .	unintelligible	3·7	5·6	discomfort

Provided that the loudness level of speech, accurately reproduced through a valve hearing-aid, is raised to intensity levels 100 to 110 decibels above normal threshold, two of these deaf subjects can hear speech with a degree of accuracy which is considered satisfactory in telephone engineering.

Speech at the intensity level of 100 decibels also leads to the best results for the nerve-deaf patient, G. 3, although she can obtain only limited, though useful, help.

CHAPTER XII.

TOTAL DEAFNESS FROM INFANCY. EARLY CHILDHOOD.

A CHILD is rarely said to be deaf before the age of two years. Deafness may often be suspected earlier, from about the end of the first six or nine months onward. It may be confirmed by observation of a child's reaction or non-reaction to sounds. As a rule, it is not until he reaches the age at which he should normally respond to speech, but fails to do so, that an opinion about his deafness can be given with any degree of certainty. In the mind of the parent there is always hope that the fear of deafness may be unnecessary and that the child's speech development is merely delayed. Until the diagnosis of total deafness is definitely pronounced, it is natural for parents and relatives to think and to act towards the baby as if he can hear. This happily and surely tends to normalise his development and behaviour, and may partly account for the difficulty in diagnosing deafness in infancy.

It is usually after a child is known to be deaf that the attitude of his family and their friends towards him changes. They begin to think of him and to behave towards him in a much less normal way. "He is deaf." The words burn themselves into the minds and hearts of all who people the child's world. Henceforth deafness is a dread reality to be reckoned with and taken into account at every stage in the child's development.

After birth hearing is the last of the senses to function. For the first few hours of life, therefore, the normal and the deaf infant have exactly the same sense experience, but never again can the conditions which result in learning and development be identical for both.

The early outward behaviour of the deaf infant may appear and usually does appear like that of a normal child. Both deaf and hearing babies make similar random movements

and cries. Reflex movements in response to external stimuli are equally natural to both, though for the deaf child they are more limited, since he can only respond to stimuli through four instead of five senses. This limitation appears to modify also to some extent general associative activity. For instance, when a dog comes near and barks, a normal baby may jump when he hears the bark, the jump being merely a reflex response to the sound of barking, but the child may also see and smell the dog. The sound, sight and smell of the dog combined enrich the baby's sense experience more fully than is possible through sight and smell alone. In addition there is a particular connection being laid between certain states of feeling and sound. Such connections together with the instinctive tendency to use voice are the roots from which speech grows later. The speech instinct acts as a starting-point for using words, and hearing offers the stimulus to set it going and the way of learning to speak.

The instinct for speech is as strong in the deaf as in the normal child, but for the former the normal way of learning to speak is closed. The deaf infant uses his voice naturally in crying, gurgling, laughing and babbling during the first months of life. The tones of his voice are always natural and are true colour-tones of states of feeling and emotions.

Deafness cannot be detected from the tone of voice in infancy nor from the earliest forms of babbling. The writer has known a number of infants who later proved to be deaf. In three instances she saw the babies almost weekly for periods over 2 years or more and had opportunity to watch their development from birth. There was a history of deaf parents and grandparents in one case and of a brother or sister in the other two cases. All three babies cried and gurgled naturally from birth. They cooed, grunted and babbled naturally. At a later stage they even appeared to respond in the usual way by smiles and babbles to the voices and talk of other people. Obviously in each case response must have been to the expression of the face, personality or situation and not to the sound of voice, but all three infants instinctively used natural voice as a form of response.

It is important that a baby suspected of being deaf should be encouraged to babble, and to use voice on every possible occasion. Babbling is an essential stage in normal speech

development. It prepares the way for speech proper by facilitating the action of the organs of speech in a pleasurable way. A normal baby gets satisfaction from babbling because he can enjoy the sound of his own voice, the feeling of the vocal movements he makes and the growing sense of power and fulfilment which using his voice gives him. Two of these three sources of satisfaction are also possible for the deaf baby. He, too, though perhaps to a lesser degree, can enjoy the feeling of mastery over his vocal organs and a sense of fulfilment when he uses his voice. This sort of satisfaction comes from using voice, not necessarily speech, even in adult life. The early morning singer in the bathroom sings because he enjoys the act of singing as well as its effect. He bursts into song because of a feeling of well-being, which finds outlet in vocal movement and sound. Many totally deaf boys and girls who have been taught orally take pleasure in what they call "singing." This to the normal listener is not song but a form of rhythmic speech with a little accompanying modulation of voice.

In the second half of the first year the babbling of the normal child usually begins to change its nature. It becomes more purposive and it begins to reflect the tones of voice and some of the sounds which he hears. There is at the same time a growing understanding of words and definite response to some of them. It is at this stage that the deaf baby's behaviour begins to be noticeably different. He fails to respond in the expected way to sounds and words. In other directions his development may appear, although it cannot be, quite normal. For the normal child who hears speech more or less during all the hours he is awake, paths are being facilitated for the passage of words in the brain. Through babbling and attempts to imitate some of the words he hears, associations are being established which enable their utterance. Mental development and speech development hurry along hand in hand. They are interdependent. An enormous leap forward takes place when the child begins to talk. He makes use of words in thinking, in understanding the thoughts of others, and in expressing his own thoughts and wants. He is learning to handle a tool which can help him in his search for knowledge in every direction. Speech, and reasoning through speech, play a big part as guiding forces in controlling, repressing and directing the instinctive tendencies in childhood.

What of the deaf child who is dumb because he is deaf to words? He cannot use words in his thinking, understand the speech of others nor express his thoughts and wants accurately in any form of symbols which other people can fully understand. The mental development of even the most intelligent untaught deaf and dumb child is essentially retarded as a result of his lack of speech. Crude gestures and signs are clumsy symbols to manipulate, and they express thought less exactly than words. Moreover, they are not the symbols in common use.

Education for the deaf child like that for the normal child aims at giving him opportunities which shall lead him to fulfil physically, mentally and socially the best of which he is capable. That best cannot be reached nor developed without the use of words, although without words, a measure of service to the common cause is possible. An intelligent deaf and dumb youth can, for example, become a very good bootmaker. His workmanship may be as good as that of the average man whom he would serve with his hands but with whom he could not communicate freely if at all. Without words he must remain one of an isolated group. His social life would necessarily be confined and limited to persons like himself. No other physical handicap, except mental derangement, and no form of class distinction, can isolate so completely as deafness and dumbness. Blindness never isolates. It draws sympathy from the hardest heart and wins friendly help and intercourse on every hand.

The main aim of education for the deaf child is to give him words—to think with, to understand the thoughts of others and to enable him to express his thoughts. Through words he is led to knowledge of himself, of the world, and of his place in and contribution to it.

As soon as a child learns to walk he is enabled to find out many things for himself. He handles, pulls, pushes, tears and plays with anything and everything. The normal child is linking words to the sense experience he gathers, and in time words come to stand in his mind as symbols for the actual experience, object or action. He is learning also to describe his experience in words.

The deaf child at the same age acts outwardly in much the same way, but he cannot connect his experiences with words. The question then arises: "In what symbols can he recall,

for example, the experience he gains through knocking his knee against the leg of a table and how can he describe what has happened to another person who has not seen the accident?" He may recall the smell of the wooden table leg or its smoothness, roughness or hardness; he may have a visual image in his mind of the table leg. The words "table-leg" sum up for the normal child all his ideas about the object. Is there a symbol in the mind of the deaf child which sums up all his ideas about the table-leg, and if so what form does the symbol take? From observation of many untaught deaf infants we know that an intelligent deaf child can as a rule find a crude way or ways of expressing "table-leg." If he wants to explain the bruised knee to his father who was not present when the impact of knee and table-leg happened, he would probably point to the bruise and then run to the table-leg or point to it, if he and his father were in a room where there was a table. But if he were in bed and there were no table in the room, he would follow one of three courses:

(1) either he would refrain from explaining what he was longing to tell because of the futility of trying—and a sense of frustration would follow, possibly also of repression;
(2) or he would point to the leg of a chair or to a leg of the bed, in which case he would give an inaccurate idea and he would not express the thought in his mind;
(3) or he would try to draw a table-leg in the air and so describe his visual image by gesture.

His father might or might not understand exactly what he meant, for the vague gestures which satisfy the young deaf child himself are not necessarily clear enough to be descriptive of the object. A child usually knows when he is understood and if he feels that his gestures do not convey his meaning, dissatisfaction is bound to follow. Such unsatisfactory situations are occurring all day in the life of a young deaf child. He is often described as passionate, uncontrolled, bad tempered, destructive. When it is true, surely it is understandable in the light which modern psychology can shed on behaviour and on the problems which arise from deafness and dumbness.

Between the ages of two and three the deaf child, like the

normal child, develops quickly. He gains fuller control over his body: his interest in his environment extends: he loves to feel his own power to manipulate and to master things. The urge to express his feelings and thoughts is very strong. He *must* find an outlet for the thoughts that well up in his mind. Consequently he makes increasing use of gesture. The more intelligent he is, the more inventive of gesture he becomes; the more observant he is, the more graphic are his gestures. It is paradoxical but true to say that gesture language at this stage is the deaf child's mental salvation and yet at the same time it is the greatest threat to his future mental life. While his thoughts are simple he can, though only to a limited extent, make many of his wants known by gestures. They can and do bring him most of the material things he desires. Because he cannot be reasoned with and because he expresses his wants very forcibly and graphically, parents, as a rule, in their sympathy and longing to appease, satisfy the child by giving him what he wants, unless it is physically harmful. In the latter case, they have no way of explaining why the thing is withheld. Their only measure is to withhold. The effects of continued appeasement can be very harmful. The child may begin to be more and more satisfied with gesture as a means of communicating a very limited range of ideas. Habits are being formed which later will militate against the development of speech. Explanations as to why?, when?, where?, who?, which lead the normal child's thoughts from himself and direct them towards reasoning and consideration of other people besides himself and other conditions besides his own, cannot be given to the deaf and dumb child. The continual appeasement of his wishes and the limited range of his interests drive his thoughts inwards and direct them towards material wants, which he finds he can secure as a rule by demonstrative persistence.

The early period of childhood is particularly important because it is during this time that the finer tendencies can be encouraged in the family or in the nursery school, and the more undesirable tendencies can be controlled and guided. The normal child is realising himself and his social environment, while the deaf child is realising himself in a more limited way because his experience is predominantly physical. He is beginning to know dimly that he is different from other people.

He begins to think about himself more than is normal or healthy for such a young child.

It has been pointed out that a deaf baby babbles and uses his voice naturally in infancy and that as a rule he continues to use his voice in early childhood. Most of the two-year-old deaf children we have ever known have had pretty voices, whereas the majority of the untaught seven-year-old deaf children have ugly, hard, heady, nasal, or weak voices, or occasionally no voice at all. Parents and teachers are bound to ask themselves what happens to the natural voices which are lost and never recovered ?

The early vocal sounds the deaf baby makes are expressive of states of feeling or of emotions. Later when he babbles he is probably enjoying a sense of mastery over his vocal organs, in the same way that he enjoys wagging his hands and feet. Later still he enjoys the feeling of the rhythm of babbling.

As he develops he ceases to be interested in mere movements. They become purposive. Apart from drawing attention to himself and his wants by inarticulate cries (and the realisation that that is possible is dependent upon the response of other people), there is no longer any reason for him to use his voice. Left to himself he may begin to use voice less and less and to rely on gesture more and more. If also other people use gesture to him, his interest and attention pass from faces to hands. Thus the babbling habit is discouraged instead of encouraged—the child's perfectly normal vocal apparatus gets little exercise and may even fall into disuse and the natural voice be lost for ever.

Both breathing and vocal apparatus are exercised and controlled during babbling and therefore the deaf child who babbles is better equipped physically to learn to speak just as he is more prepared mentally for speech than the non-babbling deaf child. It is from babbling and through babbling that the deaf child's speech can be developed most naturally.

Important reasons for the early education of deaf children have been considered. It has been shown that the period from 1 to 3 years is vital for the best mental and speech development of the child, and that the acquisition of speech and language condition later his social life and outlook.

Since the main purpose of this chapter is to discuss the peculiar difficulties which face the child born totally deaf in

learning to speak and the principles which underline his education, it seems necessary that the writers should explain the educational aims they hold. They accept the view expressed by Nunn that "Educational efforts must, it would seem, be limited to securing for every one the conditions under which individuality is most completely developed—that is, to enable him to make his original contribution to the variegated whole of human life as full and as truly characteristic as his nature permits; the form of the contribution being left to the individual as something which each must, in living and by living, forge out for himself." [1]

The deaf child cannot fulfil himself in any direction without the common means of communication—speech. Without the use of words thinking must be both hindered and limited. Without words the main way to fields of knowledge outside his own experience is closed. Nunn's definition therefore, if applied to the education of the deaf, needs the addition of a corollary—that a fundamental aim of all educational effort must also be to promote in the deaf child the understanding and use of words, common symbols used by man in thinking and in communicating his thoughts.

In England and Wales education of the deaf is compulsory from the age of 5 to 16 years, but fortunately there is an increasing number of school authorities and parents who wisely make provision for training to begin at the age of $2\frac{1}{2}$ or 3 years.

It has sometimes been suggested that a good nurse or kindergarten teacher without special training or previous knowledge of deaf children can fulfil all the requirements of nurse or governess to the 2-year-old deaf child. On the contrary, experience has proved that only a skilful teacher with both understanding of deaf children and of speech development is capable of dealing with the very delicate and crucial task of developing the child's speech from his instinctive babbling and of making at the same time the most natural approach to lipreading. No amount of meaningless practice in babbling can help the deaf child's understanding of the purpose of speech, valuable though it is as a form of voice exercise preparatory to speaking. The skill of the teacher is needed to bring about in the deaf child's mind the association between word and meaning.

[1] Nunn, T. P., 1921, *Education, Its Data and First Principles*, p. 5. Arnold.

Chapter III of this book deals with lipreading, and an explanation is given of the vagueness and incompleteness of the *seen* word pattern as compared with the *heard* word pattern. The teacher's skill can be a compensating factor which helps the deaf 3-year-old, step by step, to perceive the spoken word pattern and to associate it with its meaning.

The satisfaction which the young normal child finds in his early attempts to talk encourages him to repeat the same words and to attempt other words. A feeling of satisfaction is a vital condition of all learning, including the acquirement of speech. There is also another essential. The words uttered must be understood by other people. Because the normal child can hear the whole of his own and other people's words he is in a position to correct his own approximate imitations of words. Thus he learns to copy more and more exactly the word patterns he hears in his environment. In time he comes to realise that words serve him best when they can be understood readily and make his wants and thoughts known. Each step forward in normal speech development follows naturally and simply from the child's capacity to hear, at every stage in his early development, his own speech and that of other people.

The position of the born deaf child with regard to speech is very different. He can learn to talk in spite of the abnormality of deafness but he must learn both to lipread and to speak by artificial means. It is a colossal task for a young child, but it is being accomplished by many congenitally deaf children up and down the country. How many foreign languages does the average Englishman learn to speak fluently? Yet the acquisition of a foreign language, under normal conditions of learning, is child's play compared to the difficult course that lies before the born deaf boy who has to acquire his mother-tongue artificially.

It would not be easy for an adult, who had suddenly become deaf in manhood, to learn to speak a foreign language in spite of the fact that all his previous mental experience had been associated with speech. It is because the acquisition of speech by a born deaf child is such a vital and difficult matter that the scientific knowledge and art of the trained teacher is necessary from the beginning. She must be ready at any moment to link the child's interest in objects, persons and experiences to words. Without forcing or compelling his

attention in any particular direction she must create and seize natural opportunities of bringing the same words to his notice again and again. She must encourage him also to recall words and to try to imitate them. Left to himself it is unlikely that he would attempt to say them. Normally a child who can hear is encouraged to talk over a period of many weeks by parents, nurse and other people, before he actually begins to talk. His understanding is far ahead of his use of words. When asked he will usually point out different objects some time before he names them spontaneously.

Through lipreading, in the first place, the deaf child gleans something of the purpose of speech. He, like the normal child, learns to point to this and to that person or object by request. A little later, in proportion to his native intelligence and the teacher's skill and encouragement, he will begin to imitate some of the words he can lipread. A spontaneous imitation of a word, deliberately framed by the child's lips to express an appropriate idea, is the first step towards speech proper.

Every word the child attempts to utter must win response, and above all he must be given the satisfaction of knowing that his words are understood. He must be encouraged also at every turn to use words instead of gestures.

At first when imitating a word he does not necessarily use his voice. He may shape silently with his lips the movements he has observed on the lips of others. Here again, through the rightly timed suggestion of the teacher, he can be led to connect the use of his voice in babbling with his approximate imitations of what may be called " skeletons " of words seen. At every step in the " march of events " which brings about the development of speech in a deaf child, the teacher must be at hand to point the direction and to urge the child to take the next step forward. He cannot travel alone along an unknown path, steep and hard-going at every turn.

Diagram 67 illustrates normal speech development. Words produced at B are imitations of the word patterns offered at A. Because the normal child can hear every part of a word pattern, he is in a position to match his own words to the patterns he hears. Thus through hearing he unconsciously compares his own with other people's pronunciation.

Diagram 68 illustrates speech development in a child born totally deaf. He can be trained to perceive word patterns

through sight and touch, but when he talks, he cannot easily match his words in detail to the patterns he can perceive, for normally he cannot, unless through a mirror, watch himself speaking. He is forced to rely on the sensations of touch and

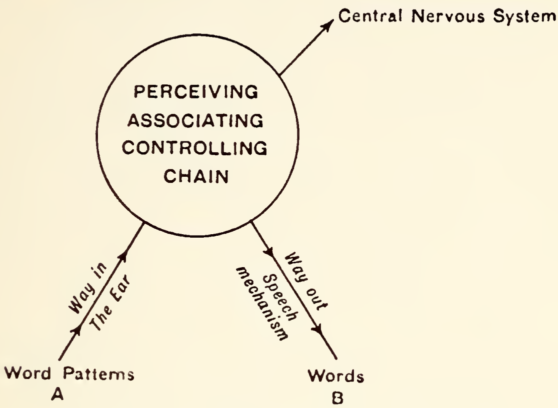


DIAGRAM 67.—Normal speech development.

movement when he speaks, and on vision when he lipreads the speech of other people. He can neither hear his own words nor appreciate the sound of his own voice, though to some extent he can by special teaching be trained to modulate it through

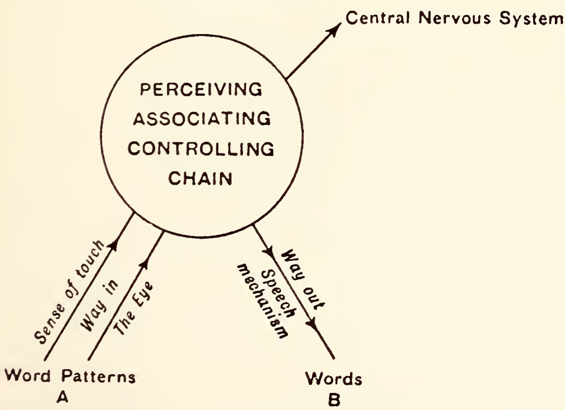


DIAGRAM 68.—Speech development in a child born totally deaf.

his sense of touch. Without help he cannot correct his own approximate imitations of words as can the normal child. Even when not especially attending, the latter hears the same words over and over again both when they are addressed to

himself and when they occur in his presence in the conversation of other people. Obviously the deaf child has only too few opportunities of seeing and recalling words. Moreover, he only sees them when he gives the whole of his attention to them and when he is looking at the face of the speaker.

The deaf 4-year-old, like the normal child at the same age, is much more interested in individual than in co-operative play. Both love to handle things and both learn through their senses and are interested in colour, size, smell, taste and in movement of all kinds. The tendency in the young child to want to play by himself is an asset to the teacher who is intent on rousing his interest in lipreading and speech, for she can do this best, in the first place, through individual teaching. But there is another aspect of the development of the deaf infant to be borne in mind. His social experience has been more than usually limited on account of his deafness. He is probably very self-centred and determined to get what he wants. It is important that he should mix with other children as soon as possible and learn something of the law of give and take. This training follows naturally as soon as he attends a school for the deaf. There, as a rule, he very quickly adapts himself to new conditions and happily takes his place as one of a group of children like himself.

The great advantages which life at school brings are inevitably accompanied by one disadvantage. The child's use of gesture increases, because young deaf children can only communicate with each other in that way. This objection, however, is far outweighed by the greater value of school life and training. In a modern infant school for the deaf, the teaching staff, while not forbidding gesture, the only natural means of communication possessed by the child, will work tactfully and ceaselessly to supplant its use by speech. For the deaf child who is educated privately it is urged strongly that special arrangements be made for him to meet other children of his own age who are not deaf. The writers know a number of deaf boys and girls who, in addition to special individual daily teaching have attended a good kindergarten school for a short time each day, or at least for several times a week. They have shared very happily in handwork lessons, dancing and games and have enjoyed thoroughly the companionship of their schoolmates. Obviously this plan is not practicable for all deaf children but

for the " only " child it is particularly valuable because it encourages normal behaviour and the use of speech and discourages the use of gesture. It helps the deaf child to begin early to find his bearings in a hearing world in a pleasant and natural way. This plan is only successful if the child is given regular daily individual teaching by a qualified teacher of the deaf, and if there is a suitable kindergarten school in the neighbourhood whose headmistress is sympathetic and willing to co-operate.

The education of the deaf child from three to seven years, privately or at school, follows the normal trend. The methods of Froebel, Montessori and Decroly all have their place in infant schools for the deaf to-day. Lipreading and speech are linked to all lessons. Teacher and child live together and constantly share experiences. Slowly but surely day by day words begin to play an active part in the child's mental, physical and social life.

CHAPTER XIII.

LATER CHILDHOOD.

From about the age of seven onwards a deaf child usually becomes more interested in co-operative activity of all kinds, and begins to enjoy the competition which group games and class teaching provide.

Lipreading and speech take on fuller meaning, when he realises that words are not merely a go-between for himself and his teacher, but that they serve with other people also.

Day by day vocabulary is increased. As soon as a beginning in lipreading has been made reading is taught. This also strengthens his comparatively small stock of language. The early introduction of reading as the accompaniment of lip-reading is advocated strongly because, in the printed word, for the first time, the deaf child meets complete and normal versions of words, by contrast with the skeleton versions he sees. Thus his understanding of words will be clearer and both lipreading and speech will be facilitated

Very soon the teacher is brought face to face with a vital problem which underlies the development of speech and language at every stage in the deaf child's education. Apart from the use of words his mental age, general intelligence and practical ability may not be retarded but his understanding and use of words lags far behind.

The three or four-year-old deaf infant is interested in naming objects as he handles and plays with them, but the boy of eight has long since lost interest in mere objects as such. He is more concerned with their purpose, construction and adaptability. What ?, where ?, when ?, how ? and why ? frame the questions in his mind, though not on his lips. The words which he will acquire most quickly and easily, irrespective of their length or difficulty, are the words which express his thoughts and his desire for knowledge.

This is a bedrock principle upon which the modern teacher

of the deaf bases her methods of developing speech and language at every stage. It requires great skill and adaptive cunning, (1) to present relatively advanced ideas in such simple words and sentences that they are within the very limited comprehension of words by the deaf child ; and (2) at the same time to introduce a proportion of new words and phrases or new sentence patterns, for it is her steady purpose to extend the child's vocabulary and language knowledge.

In the junior school lipreading, speech and reading are consolidated. Through living and doing, the child is introduced to the names of objects and actions, to the words relating to number, qualities, possession, time and place. Thus without his being aware of it, nouns, verbs, adjectives, adverbs, prepositions, conjunctions and pronouns begin to creep in an orderly way into the deaf child's understanding and speech.

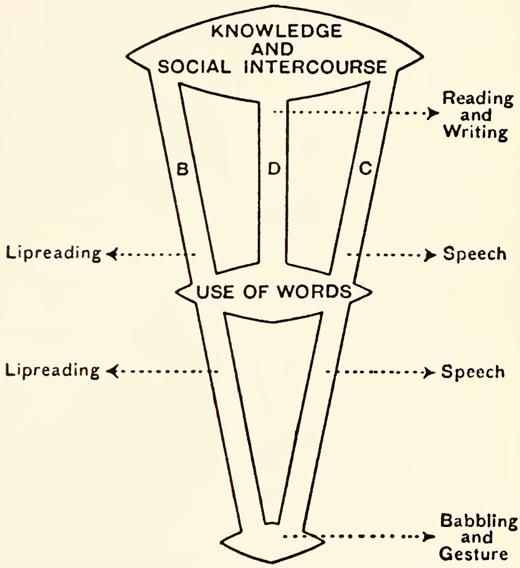


Diagram 69.—Factors in the education of a deaf child.

The teacher brings all this about. She prepares the ground, sows the word-seeds, nourishes every sign of growth, every word-shoot the child puts forth. He himself is scarcely aware of his growing satisfaction in the use of words, nor of the advance he makes, as he glides from the one-word stage to the use of simple sentences.

It is not proposed to deal in detail with the methods of teaching which are applicable to deaf children, but to outline the part words play in oral education, and to draw attention to certain of the more difficult features of the subject.

The above diagram illustrates the way in which the deaf child progresses towards knowledge and social intercourse.

From gesture and babbling lipreading and speech are slowly developed, and the child begins to make use of words in understanding the thoughts of others and in communication.

Lipreading, reading (and writing) and speech are welded into a unity, through which he not only gains knowledge of school subjects, but which, at the same time, is a source of new vocabulary and language experience.

The channels B, C, D together lead the way to further knowledge and social intercourse.

The junior school period is usually one of definite advance in every direction. Lipreading becomes more and more a process of building up thoughts expressed by other people, and not merely, as in the earlier stage, the recognition of single or very simple thoughts. The speech of the deaf child at this time becomes more intelligible and less approximate. Skilled teaching and continual practice enable the child to articulate every vowel and consonant with increasing accuracy and facility.

Reading brings a new interest all its own, provided that the subject-matter is suitable to the child's mental age and that the words are within his understanding.

The term " reading " in a school for the deaf does not imply the ability to read printed words aloud correctly, but to understand the meaning of printed words when read silently. The question of reading and of the suitability of books is of paramount importance. Ordinary picture and story books, written for the normal boy of eight or nine, are, as a rule, admirable for the deaf boy as regards subject-matter, but their wording is far beyond his comprehension. A deaf boy of ten would be just as thrilled as a normal boy by the adventures of Robinson Crusoe when seen on the cinema, but he could not possibly read and understand the words in which the story is told in the original book. The vocabulary and sentence construction used would be far beyond his experience in language. Unfortunately there is not at present a large supply of books which can be put into the hands of the deaf child at this stage, and which he can read for pleasure by himself. A judicious teacher is always on the watch for the abridged editions which usually are also simplified.

In the infant school reading will have been taught by labelling, matching and sentence building, to the standard of

language attainment reached, but between that very simple and limited form of reading, and books which are appropriate for the ten-year-old child, there is a very big gap. The deaf pupil cannot bridge that gap in two or three years. Compared with the normal child he acquires speech and learns academic subjects slowly, not because he is less intelligent, but because of the ever-recurring " hold up " in communication between him and his teacher, and because he learns under harder conditions. It must be remembered that he makes a delayed start and that he is very heavily handicapped throughout his course. He has also to meet and overcome all the usual obstacles which lie on the road to learning, in spite of his late start and severe handicap.

Early reading lessons for deaf children always need to be carefully planned so that the majority of the words used are already familiar. From the beginning, reading should be made a daily source of pleasure. How far this aim can be achieved depends largely upon the teacher's choice of reading matter and her ingenuity in presenting it simply. If day by day from junior to senior school the deaf child is offered reading material which really interests him and which relates to experiences within his comprehension, expressed in words he can understand, he can and in many instances does become as keen a reader as many normal children.

From the first he must find entertainment in what he reads. At a later stage he should be led and encouraged to seek knowledge from books. They can spread before his eyes feasts for his mind, of which he cannot partake in any other way, and which cannot fail to enrich his impoverished ideas about other people, places, times and conditions, as well as his meagre stock of language.

It has already been pointed out that words and sentences are seen by the deaf child in their entirety for the first time when they are written or printed. Clearly therefore reading can help understanding of words, speech, lipreading, sentence construction and oral and written expression in an unique way. The balance must be kept between " talking " or " oral " lessons and reading lessons. The former more directly influence the deaf child's social attitude ; the latter help progress in language and school subjects and also make more definite his intellectual attainments.

In the intermediate school the art of speaking presents a new problem.

A boy of eleven or twelve has complicated thoughts which he wants to express quickly. He has not patience to think consciously of the utterance of every word he uses, and correct articulation is, as yet, very rarely, if ever habitual or automatic. It would be too laborious if it were possible for him to think out the production of every sound in every word. Because he has more to say and because he uses longer sentences, he speaks more quickly and eagerly. He runs words into each other and he often misses out sounds which are essential for intelligibility. The temporary loss of intelligibility in speech at this stage is an indication of progress in both mental and speech development. Nevertheless the purpose of speech fails if it is not intelligible, and the boy, whose words habitually fail to be understood, will lose faith in his own ability to speak, in speech itself, and in those who do not understand him when he talks.

May the writer be pardoned if she digresses? She has wondered often what goes on in the mind of a deaf child when words burst from him, because he is longing to express his thoughts, or to know something, and the words he utters are not understood. He is expected to repeat them patiently all over again, probably even a third or fourth time to make the listening adult understand. But when the boy himself fails to lipread the words of other people, *he* is expected to try and try and try again until *he* can follow *their* speech.

Does the traffic seem to him to be all one way? Is all the effort to be made by him, both when he speaks and when he tries to lipread? Are these breaks in communication entirely the boy's fault? Some of them surely are, but many of them are due, at least in part, to lack of understanding in the adult about the kind of help he could give. Perhaps the first question he should ask himself is, why the boy failed to lipread. Could he see? Were the words not spoken distinctly enough, or were they outside his vocabulary? Failure to lipread is nearly always due to one or other of these reasons.

To return to the question of speech. Through more advanced forms of rhythmic speech the deaf child can learn to control and to modify his rate of utterance, the individual values of vowels and consonants and of phrasing, accent and

emphasis. Dramatisation, plays, dialogue, poetry, even reading aloud are all pleasurable means which can be used to help the boy to attain a standard of intelligible speech.

In the senior school, in addition to the forms of practice already suggested, we have found that a more adult approach to the study of speech is very helpful. This relates the theory and practice of elementary phonetics to a simple and practical study of the functions of each part of the speech mechanism.

The adolescent deaf boy and girl can be led to think of " talking " in a new way. He can compare his own study of English to that which the normal boy pursues when learning French or German. He, like the normal boy, must realise his own responsibility to speak intelligibly and the rules which condition intelligibility in his particular case.

Throughout the school, alongside the learning of lipreading, speech, reading and school subjects, runs the development of character. For example, how can a boy deaf from birth grow into a sympathetic man ? To feel sympathy is the result of imagination. Imagination is roused by realising the experiences of other people. The deaf child sees and observes what happens to others when he is present but he has few natural opportunities to learn about their experiences in general. Obviously the answer to our question lies in the provision of the right kind of education, which will offer very frequent opportunities for the boy to observe as widely as possible the conditions of living and work of many different kinds of persons.

At this time his growing ability to talk and lipread, and to read, should put him in a position to find out for himself more about people, conditions and places.

Another vital question must be faced. How can the deaf boy or girl be prepared for the mental and physical changes which occur at adolescence ? Again the same answer applies. The right type of education from the beginning will encourage the child to observe and to study the habits of plants and animals and to realise the facts of growth. Every subject—English, Arithmetic, History, Geography, Scripture, Nature Study, Elementary Biology—should be taught in a very practical way. Every activity—Physical Training, Games, Swimming, Life-Saving, Dancing, Scouting and Guiding—will not only help the growth of his body and add to his experience and knowledge, but it will also be a source of new language and provide new

opportunities for social contact. From the age of three to the age of sixteen (and after whenever possible) he must learn through doing and seeing. This is no new principle. Pestalozzi, Froebel, Montessori, Margaret McMillan (even Mr. Squeers though differing in motive) have supported the doctrine of teaching by doing. In the education of the deaf child this is a fundamental principle. The linking of words to what he does, sees and thinks, causes their fusion into his mental and physical experience. Speech and language are not merely school subjects to be taught in the classroom only, they are an essential human characteristic, whose natural growth is denied to the born deaf child, but who, through education, can attain to them. Speech and the upright position are such vital parts in the life of man that they are the two chief outward features which differentiate him from the beasts that perish.

CHAPTER XIV.

EDUCATION BY THE HEARING LIPREADING METHOD.

SPEECH.

For the first time in history, powerful and reliable apparatus is available, by means of which 70 per cent.[1] of the children who are born deaf, or who acquire deafness during infancy, can be enabled to use their ears, although in many instances only to a very limited extent, in learning to talk.

This statement offers a challenge to all who are interested in the education of deaf children.

It does not imply that they can be taught by normal methods through a hearing-aid ; nor that they need only to listen through an aid to be able to hear ; nor that they will ever speak like people with normal hearing. Our challenge claims that although speech can be stimulated in the majority of deaf children from an instinctive tendency to babble, it takes on new meaning for the child who can be enabled to hear the sound of human voice with or without a hearing-aid. His whole mental life is stirred. The mere sound of voice arouses an instinctive response to speech which can be excited in no other way—the ear is the one and only " way in " for the *sound* of speech to reach the brain. It has been shown that a totally deaf child can be trained to feel and to appreciate the vibrations which constitute voice, but obviously he cannot experience the sensation of sound through his sense of touch. As a rule even a child, who has no more than an island of hearing, can be enabled to hear something of the sound of his own and of other people's voices through an efficient powerful amplifier.

[1] Ewing, I. R., and Ewing, A. W. G., 1936, " The Use of Hearing Aids in the Treatment of Defects of Hearing in Children," *Journal of Laryngology and Otology*, 51, 4, p. 1.

It has ever been a pleasure to human beings to hear their own voices. The favourite companion of many a man or woman is the sound of his or her own voice. The writer is reminded of a small deaf boy whom she knows. Originally he was believed to be totally deaf and he was being taught as a totally deaf child. He has since proved to have a small island of residual hearing. When he first listened through a powerful amplifier to the sound of the writer's voice and later to that of his own voice, he appeared puzzled by what he heard. He tried to open the amplifier to look inside—murmuring " bow-wow," a word he had acquired through lipreading. When he was shown the contents of the amplifier, he shook his head again and again said " bow-wow," or, in other words, " no dog inside." At some previous time he must have heard, probably very dimly, the bark of a dog, for it was that sound which he recalled when he heard voice through the hearing-aid. He was encouraged to speak the word " bow-wow " into the microphone and to listen to his own attempts to say the word. It dawned upon him gradually that he himself was producing the sounds he could hear. He laughed with delight and again and again returned to the amplifier to listen with the keenest pleasure to his own voice.

What educational advantage has a severely deaf over a totally deaf child ? What is the value of an island of hearing in education ? To what extent can a limited capacity to hear speech in school be of permanent value to a severely deaf child ? How can defective hearing be trained and utilised in education ? These questions are of paramount importance to parents and teachers of the deaf. There can be no final answer to any one of the problems, but in this and the following chapter the writers offer certain suggestions and trains of thought, which embody the principles underlying the methods and technique which they have evolved in their work as teachers of children suffering from defective hearing.

For the purposes of education children who have been classified as severely deaf may be sub-divided into two groups :

(*a*) Those who have only an island of hearing and are so severely deaf that they are dumb from infancy onwards until education begins. They can hear faintly with the unaided ear only a very limited number of

sounds, in circumstances which are very variable. Such vague sounds as they hear fail to interest them and are therefore often ignored.

(*b*) Pupils whose deafness is less severe, who can respond with the unaided ear to a number of sounds within the speech range. The majority in this group use their voices spontaneously as a means of expression. Some of them talk a little before education begins, but invariably their understanding and use of words are very limited and imperfect in quality and quantity.

Only a powerful high quality amplifier can enable either of these groups to hear speech to their maximum capability. As yet there are no portable valve aids powerful enough to meet their needs. During such lessons as physical training, carpentry, cookery, art and other school activities like games and scouting, it is impracticable for a child to use a large amplifier. At such times he is obliged to resort to lipreading and to his little bit of unaided hearing, unless silent means of communication be adopted such as finger spelling.

After leaving school also, in the workshop and at home, his very limited capacity to hear will not serve as his main way of understanding the communications of other people. Throughout life, from childhood to old age, he will be obliged to depend more upon his sight than upon his hearing when people address him. Lipreading must be thought of as the essential means of communication for these children, and hearing as the vital spark which sets aglow the words which are lipread and which give to them fuller and more personal meaning. The sound of voice adds an emotional appeal to words which is missing, when they are lipread only and the voice is not heard.

A young normal child gets much help towards understanding the meaning of words from the sound of the voice which utters them. It is this kind of help which a child, with no more than an island of hearing, can be given through a suitable hearing-aid.

At this point it will repay the reader to study carefully the figures in the table given on next page.

A series of tests was made with a number of severely deaf pupils. The object of the experiments was to compare the results of tests of the intelligibility of speech through (*a*) hearing, (*b*) lipreading, (*c*) unaided hearing and lipreading combined, and (*d*) aided hearing and lipreading combined.

Tests of the Intelligibility of Speech.

(*a*) Unaided hearing only.
(*b*) Unaided hearing and lipreading combined.
(*c*) With aid but without lipreading.
(*d*) With aid and lipreading combined.

(Percentage of vowels and consonants correctly recognised.)

Pupil.	(*a*) Unaided hearing only.		(*b*) Unaided hearing with lipreading.		(*c*) With aid but without lipreading.		(*d*) With aid and with lipreading.	
	Vowels.	Consonants.	Vowels.	Consonants.	Vowels.	Consonants.	Vowels.	Consonants.
1	0	0	73	50	27	11	82	67
2	0	0	No test		95	50	95	86
3	0	0	85	41	91	66	100	74
4	24	7	81	66	76	46	94	86
5	54	21	82	52	98	95	97	97
6	48	23	100	65	100	91	100	98
7	76	25	91	73	82	50	97	84

Pupils Nos. 1, 2 and 3, whose audiograms are given on pages 287, 293, 294 have only small islands of hearing. They could not hear enough to recognise any vowels or consonants with the unaided ear although they could hear the sound of a shout uttered within 2 inches of the ear. Lipreading combined with aided hearing gave markedly better results in all cases. Thus the child's understanding and use of words would be facilitated. Pupils 4, 5, 6 and 7 clearly benefit to a greater extent. The relationship between the audibility of consonants and the intelligibility of speech has already been shown.[1] Pupils 4, 5, 6 and 7 could all be enabled, with lipreading and an aid, to recognise 84 per cent. or more of the consonants given in the tests. In other words, the maximum number of complete word patterns could be given to them through the aid and lipreading combined.

There is a subtle and very valuable effect upon thinking when clear word patterns take the place of skeleton lipread words or blurred indefinite sounds. This effect constitutes perhaps the greatest intellectual benefit which can be given to a deaf child with some hearing.

Facilitated thinking in turn influences the child's understanding of spoken communications, the fluency of his speech, his rate of learning and his social behaviour.

[1] Chapter IX.

Associated with this principle which insists upon the combination of lipreading and hearing at all times, is the need for ear-training to be given often and regularly so that the child may learn to use his hearing to the maximum extent, throughout his education and in all the circumstances of his daily life.

The help he derives from hearing during his school days cannot fail to be of permanent value to him. All the experience he gains through hearing becomes part of his mental make up. He approaches nearer to normality because mental activity is continually being stirred through five senses and not through four senses only as in the totally deaf child. It must be remembered that stimulation through one of the senses sets up, as it were, a wave of general mental activity. A severely deaf child, trained to use his hearing, has a double advantage over a totally deaf child. He is continually experiencing both a particular and a general form of mental stimulation which a totally deaf child misses. Let us refer again to the bark of a dog. Let us suppose that a severely deaf child, aged three years, hears the bark of a dog, which he has not seen. He looks round for the source of the sound, sees the dog, goes to it and pats it. He immediately associates the sound of the bark with the dog—but there would also take place a more general kind of mental activity. Impressions of the dog through sight, hearing, smell and touch combine to form a more comprehensive mental picture of the dog and its characteristics. The totally deaf child, left to himself and not hearing the bark in the first place, fails to see the dog and so loses all the mental stimulation which the incidence of the dog would normally promote.

The aim of ear-training is to help a child to interpret and to assimilate all the sounds he can be enabled to hear. With this end in view from the beginning ear-training associated with lipreading is given by means of synthetic teaching.

Thus a second important principle is involved. It is in these two directions that there lie fundamental differences in our methods of teaching and the analytic auricular method, described by Goldstein,[1] which is in practice in some of the American schools for the deaf, and which was first followed by Urbantschitsch in Vienna.

[1] Goldstein, Max. A., 1933, *Problems of the Deaf*, p. 223. Laryngoscope Press.

Goldstein's and our investigations have shown that the daily use of a powerful hearing-aid over a prolonged period has not been followed by any change in auditory acuity. Clearly therefore no amount of synthetic or analytic listening can lead to improved hearing. The interpretation of sounds is greatly helped by context and by lipreading, we therefore concentrate in ear-training on synthesis rather than upon analysis. For children with islands of hearing, our approach to ear-training is through lipreading and in the case of very young children, also through babbling. For less seriously deaf pupils who make some attempt to talk spontaneously before coming to school, the approach is made directly through hearing but always associated with lipreading. A child is encouraged at every turn to piece together all the clues to meaning which he can gather from lipreading and hearing simultaneously. This mental process of piecing together is comparable to that which brings about the solution of a jig-saw puzzle. There are always two sets of clues to be discovered and associated. One set is indicated by the colour and marking of the pieces ; the other set of clues are recognisable by their shape. In constructing the puzzle we do not notice exactly how we put the picture together nor do we consciously register the form of each individual clue upon our minds. We could never state exactly how far colour or shape had guided us in constructing the whole. Thus it should be when words are lipread and heard simultaneously.

A third and all-important principle of teaching is involved in the statement that the best results for each individual child in speech, response to speech and in normal behaviour can only be achieved if ear-training is given in the early years of education. Hearing should not be thought of by pupils or by teachers as an accomplishment, but should be accepted as a natural everyday experience which promotes the growth of speech and which guides its development from its beginnings in babbling, to the use of voice and to free communication by talking.

There are two further principles which condition the success of the combined method of teaching through lipreading and hearing. One insists upon the teacher having accurate knowledge of the individual pupil's capacity to hear ; the other relates to her understanding of, and skill in using hearing-aid equipment.

The results of a series of tests (the new standard testing lists) demonstrate the significance of the first of these two principles. Audiogram A shows a typical island of hearing.

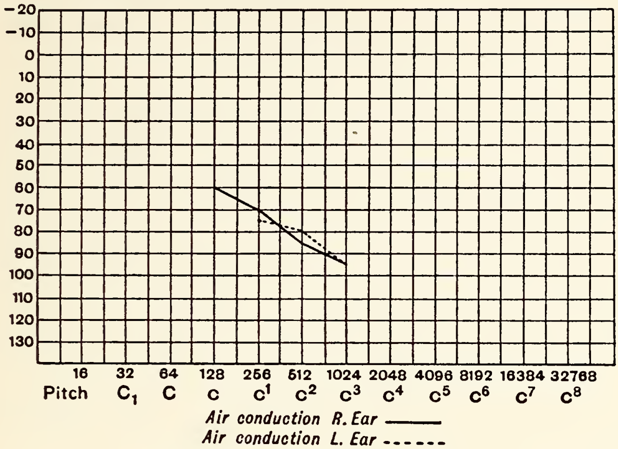


DIAGRAM 70.—Audiogram A.

This pupil was originally believed to be totally deaf; she was dumb before her education began.

Audiogram B shows a typical curve for a less severely deaf child. Before education began this girl talked a little. Her speech was unintelligible to strangers, although the tone of her voice was always natural.

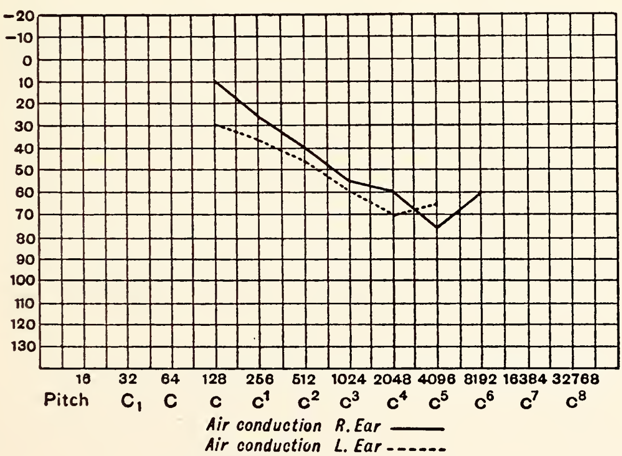


DIAGRAM 71.—Audiogram B.

Results of tests made by hearing alone (with amplifier) :

	Score.	
Patient.	*Vowels.*	*Consonants.*
A.	27 per cent.	11 per cent.
B.	82 ,, ,,	30 ,, ,,

These figures indicate in each case the extent to which hearing, even under the most favourable conditions, needs to be supplemented by teaching through sight and touch to achieve the best possible results in speech. The vowels and consonants, which are inaudible, or are only partially audible to a pupil, will always need to be developed or corrected through the senses of sight and touch. A teacher therefore should be able to analyse and to examine in detail a pupil's capacity to hear speech, and to assess accurately the educational value of an island, or of a range of hearing, from the results of pure tone tests and of the short intelligibility tests made in the classroom.

Adequate instruction in speech cannot be given by the method of teaching which is being described unless the teacher knows exactly how to present spoken word patterns in complete outline to each child. The intelligibility of the pupil's own speech will depend first upon the clarity of his images of spoken words and secondly upon his ability to reproduce words automatically.

The assessment of hearing capacity and judgment about supplementary teaching through sight and touch constitute the analytical factor which lies behind our synthetic method of teaching, but the main part of the conscious analysis involved is done by the teacher and not by the child. For this reason it is permissible for tests of hearing made in the classroom to be given in the form of meaningless nonsense syllables. They are given occasionally only, as a means of obtaining necessary information for the teacher, to be used in the interest of the child, as an aid in the development of speech. Such tests are never given as an exercise in ear-training.

The technique in speech correction will depend to some extent upon the kind and quality of the hearing-aid provided. If a pupil is to be able to hear his own words and to compare them with those of the teacher, it is essential that both he and she

speak directly into a microphone. For this purpose therefore the pupil should stand or sit close to the microphone and be encouraged to speak directly into it, while at the same time he listens. To simplify the procedure in class teaching additional microphones can be attached to the amplifier, into which the pupils, who sit at a convenient distance for lipreading can speak. This arrangement of microphones and amplifier is illustrated in the picture facing page 236.

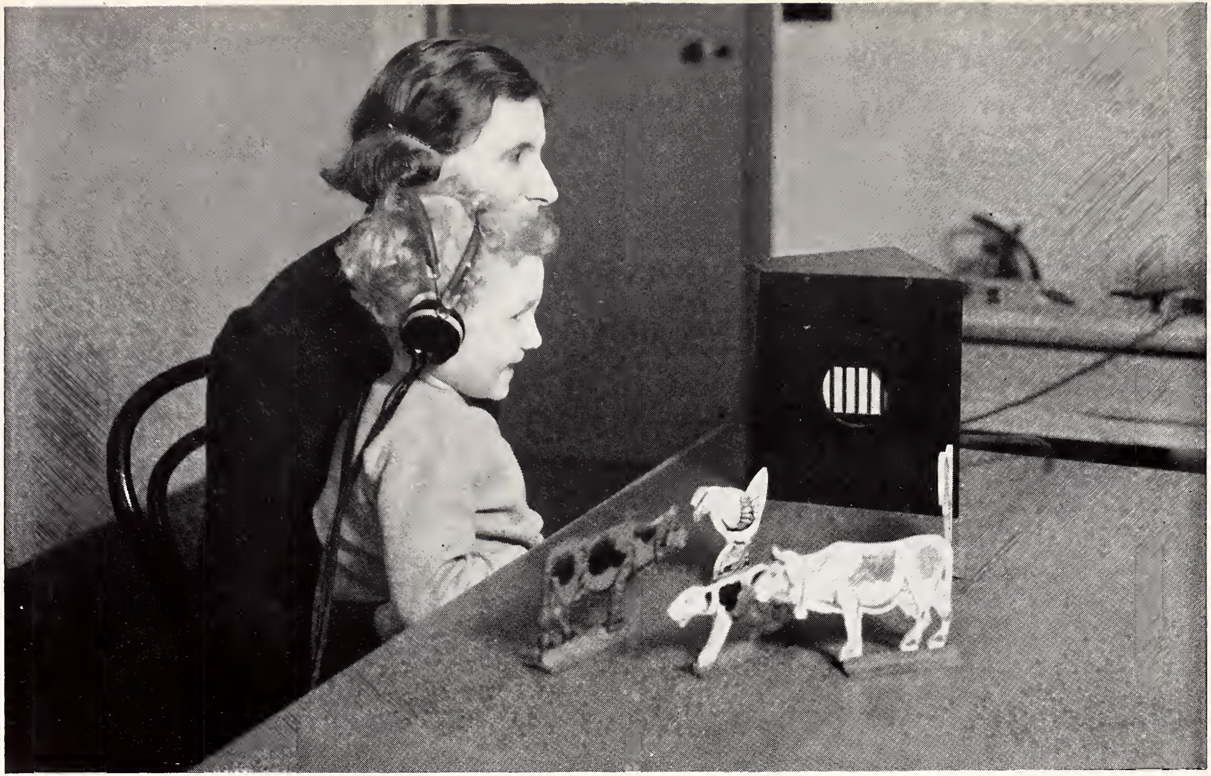
It is a principle of teaching and also a matter of plain common sense to suggest that a teacher must understand how to manipulate to the best advantage the apparatus she proposes to use. Such an obvious statement will be pardoned when the writers explain that they know many parents and some teachers who have attempted to train the hearing of severely deaf children without understanding anything at all about the capacity and management of a valve hearing-aid. In one such instance a parent did not know that batteries must be replaced or recharged. In another case a teacher was encouraging children to listen through an aid which was not functioning. These are two of many similar occurrences which point to the need in a teacher of knowledge about the aid which is to be used, its power of amplification and the accuracy of its reproduction.

In the infant school tests of speech made in the play-way give useful although not final information about a child's capacity to hear with and without a hearing-aid. Interest in and understanding of the purpose of words are brought about through lipreading. The first step towards articulate speech is taken when the child babbles into the microphone and learns to enjoy the sound of his own voice. He quickly learns to use his voice to attract attention and when he tries to say the words he can lipread. Through the microphone he can learn to appreciate the character of soft voice, high and low voice, many of the noises which animals make, the noises of laughter and of crying, of cooing and of humming. The little three or four-year-old child should not be hurried through all these experiences. Listening practice should be given daily in the form of a pleasurable amusement, as a competition or as a game. A single amplifier or one especially arranged for the simultaneous use of two or three children has proved most useful for infants. Behind the amplifier there

should always stand a mirror so that the teacher can strengthen the value of ear-training for the child by encouraging him to hear and at the same time to watch her speech and to compare her and his own attempts at babbling and talking. For instance, he may hear and imitate through the microphone the sounds "ba ba babababah" but if the teacher should substitute "l" for "b" and say "la la lalalalah" he might not (certainly would not if he were very severely deaf) hear the difference between "ba" and "la." Even if he became aware of a vague difference he would be unskilled in imitating it by ear alone. He would tend therefore to recall the group of sounds with which he was already familiar and to repeat "ba ba babababah" and to ignore any slight difference he might perceive between the two consonants. If, through the mirror, he were led to observe that the teacher uses her lips for "ba ba babababah" but that she uses the tip of her tongue for "la la lalalalah" the difference between the two movements for "b" and "l" becomes, with the help of the eye, a quite distinct difference.

When he imitates what he perceives, through hearing and sight together, first "ba ba babababah" and then "la la lalalalah," awareness comes of a new and further difference between them. He *feels* one set of movements with his lips and the other with the tip of his tongue. Thus sensations of hearing, sight, movement and touch blend together and cooperate to clarify the child's knowledge and habits of speech. Short frequent periods of practice should be given during which he listens to and imitates the teacher's voice and word patterns. He must be encouraged constantly to use his most natural tones of voice at all times, both at the microphone and away from it. It is easier to avoid the development of ugly strained tones of voice than to eradicate defects when they have become habitual; for this reason the most careful voice-training is necessary from the beginning. In the infant school babbling practice and ear-training are as a rule given individually. After a child has become interested in the sound of his own voice, it is advisable to interest him also in the voices of his classmates and of other children in the school.

An amplifier which can be used for two, three or four children enables them to listen to each other and encourages



Listening and babbling practice.

them to talk to one another. They readily learn to modulate their voices for each other's needs. Collective practice helps them to understand that which is difficult for most young dumb children who are deaf to realise—the universal vocal character of speech.

Flexibility of the lips, tongue and soft palate is essential for smooth fluent utterance. The muscular control of the organs of speech may deteriorate or fail for lack of exercise in a child who remains dumb after the normal time for speech to develop. The muscles of the tongue which are brought into play during mastication probably function normally in a dumb child but the fine adjustments of the lips, front and side edges and back of the tongue which are required for intelligible speech are not made during mastication, nor are the lips exercised as they are in talking. Babbling into the microphone is a simple way of developing flexibility in the organs of speech provided that it includes every possible combination of vowels and consonants which the child has been taught to say by hearing, sight and touch.

The interest of the child in babbling is strengthened if it is associated with rhythm. The joy which a deaf child takes in beating a drum rhythmically is increased when he can hear as well as feel the rhythm of the beat.

Voice and rhythmic training through the sense of touch has been an essential feature of methods of teaching the deaf and dumb to speak since the earliest attempts at oral education were made. There is no new theory involved, but of late there are new ways of putting into practice the old theory. There appears to be a tendency in some quarters to encourage, through training, given through the sense of touch by various means, the development in young totally, severely and partially deaf children alike the use of loud voices irrespective of quality.

The sense of touch is at present the simplest and most direct way by which a totally deaf child can appreciate that form of vibration which we call sound, but it must be remembered that only 28 per cent. of children who are deaf *are* totally deaf. The needs of the other 72 per cent. are different. A severely or partially deaf child can be given the actual experience of hearing sound, and it is vital that he be given that kind of experience as early and as often as possible and

that with it he should learn to associate his appreciation of rhythm through the senses of sight and touch.

Voice, as an expression of personality, offers an intensely interesting study in itself.[1] It can act as a powerful help or as a hindrance to meaning. The countless individual differences in the voices of normal persons are probably due to various causes but especially to the interaction between the build of the speech mechanism (the length and width of the vocal tube, the shape of the resonating cavities, the length of the vocal cords, the size and control of the tongue and soft palate) and the voice patterns heard and imitated in childhood.

The writer has observed the occurrence of a characteristic voice in several instances where two or more in a family were totally deaf from birth. A and B were brother and sister, both congenitally deaf mutes. The boy A was 2 years older than the girl B. When they were pupils in an infant school for the deaf, it was impossible sometimes to tell by hearing alone which of the two was laughing, crying or speaking. This was also true of three other totally deaf children, C, D and E, two sisters and a brother, all of whom in the early stages of acquiring speech used a characteristic " family " voice. In both cases the similarity became less as the children grew older, and it died away entirely when the boys' voices broke. Normally voice is produced automatically. A speaker who can hear and who has always been able to hear his own voice is not always capable of judging its quality. The average talker does not pay very much attention to voice production or to his manner of speech. As a rule it is the professional talker, the actor, clergyman or teacher who is expected to give thought to the way he talks. A speaker who wants to improve the quality of his voice is obliged to submit to training. Both his ear and his capacity to reproduce need practice if new habits are to be formed. It is to be expected therefore that ear-training and practice in " matching " voice and speech patterns with the amplifier is absolutely necessary to bring about improvement in the quality of the speech of partially and severely deaf children. Such practice results in improvement in three directions :

[1] Pear, T. H., 1933, *The Psychology of Effective Speaking*, p. 14. Kegan Paul, Trench, Trubner & Co. Ltd.

(1) Pupils are enabled to hear more clearly and loudly all the sounds which they can hear, no matter how dimly, with the unaided ear. Many meaningless sounds, which have been ignored previously, then become meaningful. Thus the child's capacity to hear may *appear* to increase.
(2) His ear becomes more critical and appreciative of the qualities of voice and speech as a whole.
(3) He becomes more skilful in imitating speech patterns.

Practice in imitating patterns should be given daily for a few minutes through the amplifier. The individual child, or the class as a whole, listens attentively to the voice patterns offered by the teacher as she introduces notes of different pitch, beginning with wide intervals and gradually working towards little melodies. Quality of voice can be improved by exercises which develop its flexibility and control. Loudness and softness can be demonstrated by making use of individual volume controls and also by the modification of the teacher's voice. Care must be taken not to confuse quiet voice, that is, voice of low intensity, with whispered speech, which is quite different in its effect. To the severely deaf whispered speech through a hearing-aid is very unpleasant. Words appear to be a series of fricative sounds or a vague stream of meaningless breath groups. Speech which, though quiet, rises well above the threshold of hearing gives a sensation of pleasant natural speech.

The writers advise strongly that each hearing-aid for class or individual teaching be fitted with a noise-meter to enable the teacher to measure the output of her own speech as a guide in keeping it at the best level for audibility.

One of the most interesting although at times tantalising effects of severe deafness is experienced by a listener who can just catch what we will call the sentence melody but none of the words which are being addressed to him. Normal listeners experience a somewhat similar effect when they hear voices but not words in another room, but with a subtle psychological difference. The words of people talking to each other are not as a rule the concern of a listener in another room, but those which are being addressed directly to a deaf listener are very much his concern. If they are constantly withheld his mind

begins to ache for them. He therefore makes more use of what he can hear and tries to interpret their meaning. He may recognise from the voice alone that a question is being asked or that he is being told a sad or a funny story, or that he is listening to repartee which is being retold—for he can gather all such information from the modulation and inflexion of a speaker's voice which he can only just hear faintly. He may guess vaguely the line of thought of the speaker, but he cannot fill in the details. The writer likens this effect on the mind to that which the blind man experienced when he saw " men as trees walking," and yet such sound of voice as can be caught is an invaluable and pleasurable help and guide to him. Deaf persons probably realise more acutely than most other people how much help towards the meaning of words is given by the varying tones of voice.

The speech of severely deaf children suffers seriously and is frequently unintelligible because their speech lacks modulation and inflexion. It is often very monotonous. No help to meaning is given to their words by conventional sentence melody. Questions are asked in precisely the same tones of voice as statements are made and the listener is not prepared to understand words whose meaning seems to be partly veiled by unconventional inflexion.

An amplifier can help to prevent such defects developing in the speech of children. It provides a natural way of encouraging modulation in speech. Practice in listening to and in imitating conventional sentence patterns and inflexion should be given daily through interesting stories, suitable poetry, dialogues, plays and free conversation.

The correct accent or stress on words is conventional and is best taught in relation to rhythm. Severely deaf children, who, in the first place, are dumb and who acquire knowledge of their mother-tongue only by special methods of teaching, are at a greater disadvantage than is generally understood, when they meet accented words in conversation. Unstressed syllables in a word, or unstressed words in a sentence, are often difficult to lipread because their duration is so short. As a rule also, they fall below the level of hearing required by severely deaf patients for audibility, and much below the level required for intelligibility. In this way a word, e.g. " boiler," which is composed of a stressed and an unstressed

Hearing aid apparatus in use in the new amplifier rooms. Class of boys being taught by hearing-lipreading methods.

syllable, may appear in quick speech as one syllable only, both to the eye and to the unaided or even to the aided ear. This difficulty supplies a strong reason for the constant and close association of written and printed words with their heard and lipread forms. When one knows that a word consists of two or more syllables, one becomes aware that something is missing, and there is greater readiness to fill in the gap. The writer is tempted to say that " expectation is the mother of perception," it plays so big a part in preparing us to hear, especially when there is a degree of deafness. A simple illustration will serve. When out for a walk in the country one evening, the writer happened to look at her watch and noticed that it was nearly time for church. A few minutes later she became aware of a dim sound, fragile and so faint, that it seemed like nothing more than the ghost of a church bell, rustling in the distance. Nevertheless she knew it was there and told her companion the moment the sound died away to silence. It is unlikely that she would have noticed the faint sounds of the bell in the first place, if expectation had not been roused by a glance at her watch and she realised that it was time for church.

The following measures have been found helpful in developing conventional accent in the speech of older severely deaf children :

(1) Rhythmic practice in which the pupil feels, sees and as far as possible hears through the amplifier the " weighting " of words.
(2) Constant association of lipread and heard forms with the printed word marked for stress, e.g. cārpĕt, pŏtātŏ, eīdĕrdōwn.
(3) Free discussion about conventional pronunciation. Words similarly stressed to be grouped and practised often.
(4) Familiarity with a dictionary as a guide to pronunciation.

The writers are asked very often to give detailed accounts of the way in which children suffering from different degrees of deafness respond to speech-training with the help of an amplifier. Typical instances are quoted below to illustrate what improvement can be achieved in different conditions of deafness.

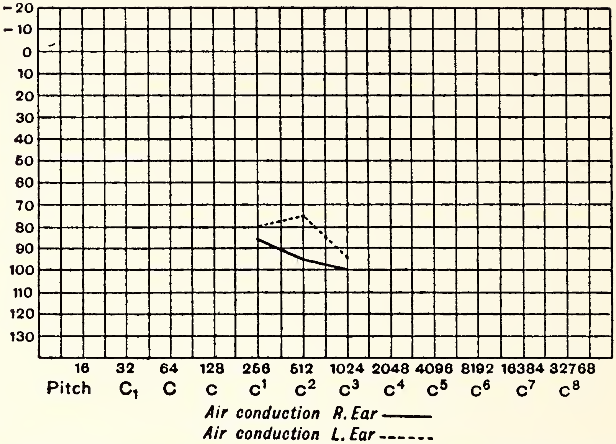


DIAGRAM 72.—Audiogram (Bee). Born deaf. Age when ear-training began, 14 years plus. (1931.)

With an amplifier this pupil can hear 5 notes within a range of two octaves. By hearing alone through an amplifier she can :

(*a*) Differentiate between five different notes sung by a male or female voice.

(*b*) Differentiate between high and low notes and loud and soft notes.

(*c*) Recognise the presence, but not the full characteristic quality, of a number of vowels and consonants.

(*d*) Control the smoothness of her utterance and modify the loudness of her voice.

(*e*) Sing a scale of five notes of different pitch and therefore to some extent modulate her tone of voice.

(*f*) Imitate stress in words, phrases and sentences through rhythm.

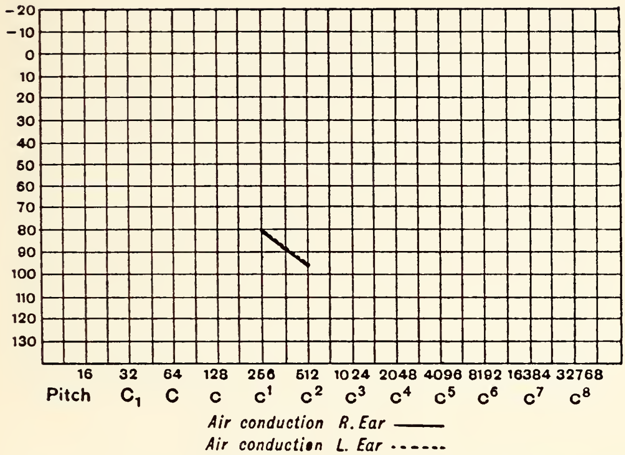


DIAGRAM 73.—Audiogram (Francis). Born deaf. Age when ear-training began, 4 years. (1934.)

By hearing alone through an amplifier this boy can :

(*a*) Recognise with certainty four different notes within an octave.

(*b*) State which notes are high and which are low.

(*c*) Recognise six out of ten vowels in short intelligibility tests.

(*d*) Imitate four different sung notes within an octave.

(*e*) Babble (i) In a high voice.
(ii) In a low voice.
(iii) In a loud voice.
(iv) In a quiet voice.

(*f*) Imitate the vowels he can hear.

(*g*) Copy stress and rhythm in babbling patterns and words.

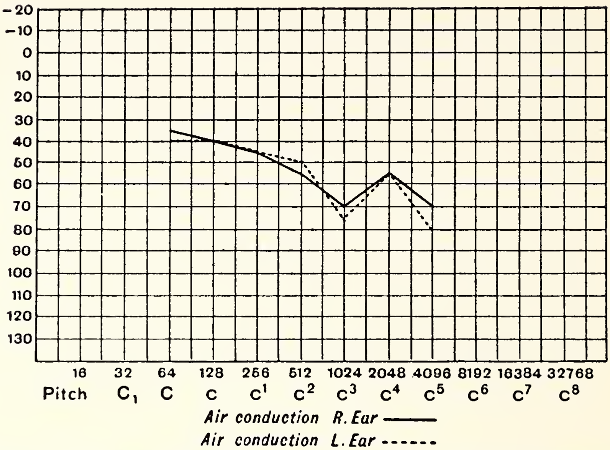


DIAGRAM 74.—Audiogram (Sam). Born deaf. Age when ear-training began, 12 years. (1932.)

By hearing alone through an amplifier this boy can :

(*a*) Recognise and reproduce sung notes over a range of five octaves by a male or female voice.

(*b*) Recognise 91 per cent. of the vowels in nonsense syllable tests.

(*c*) Recognise 37 per cent. of the consonants in nonsense syllable tests.

(*d*) Recognise 100 per cent. correct numbers spoken normally in any sequence.

(*e*) Talk intelligibly with well-modulated voice.

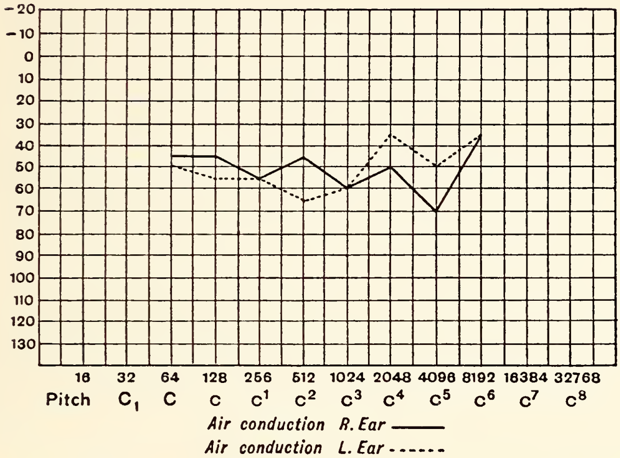


DIAGRAM 75.—Audiogram (Lily). Born deaf. Age when ear-training began, 12 years. (1934.)

By hearing alone through an amplifier this pupil can :

(*a*) Recognise 100 per cent. correct numbers given in any sequence and in any combination of several digits.

(*b*) Recognise 100 per cent. correct vowels given in nonsense syllables tests.

(*c*) Recognise 91 per cent. correct consonants given in nonsense syllable tests.

(*d*) Talk normally.

All the teaching which led to the results stated above was given by the combined medium of hearing, sight and touch.

The tests, leading to the conclusions stated, were given by hearing alone through an amplifier. The amplifiers used in every instance quoted were designed by Littler.

CHAPTER XV.

EDUCATION BY THE HEARING LIPREADING METHOD.

ENGLISH: TECHNIQUE.

In the foregoing chapter, reference was made to the incompletely heard and lipread word patterns which are received by a severely deaf child. It was shown that they are due to his inability :

(i) to hear certain sounds in any circumstances ;
(ii) to hear unstressed syllables when they fall below the required level of loudness ;
(iii) to lipread all the movements made in speech.

Similar limitations occur in his reception of sentences. He can only follow a complete sentence pattern when all its parts are either audible or lipreadable or both audible and lipreadable. Such sentences occur rarely. The mind of a child with defective hearing must always be on the qui vive to fill in the parts of words and sentences which have been missed.

In the early years of education a child who has been severely deaf from birth is not capable of filling in word gaps to any great extent because he has only a very limited stock of language to draw from. Like the born deaf child he comes to school to learn to understand and to speak, what should be, but is not until he is taught, his mother-tongue. In the course of his education he is trained and learns unconsciously how to supply the missing parts of sentences from their context. In normal speech development the understanding of words always runs far ahead of the capacity to use them. This is true also of the speech development of all classes of deaf children, who must continually try to build up the meaning of sentences from a proportion only of the words.

From her experience of lipreading and of severe deafness the writer has examined speech closely to discover which parts of words and sentences are likely to escape notice first. Take for example the following conversational sentences : " If you think it's likely to rain, oughtn't we to take mackintoshes ? for it wouldn't be sensible to get wet after having been in bed with influenza ! " Certain sounds and syllables would prove to be both inaudible and unlipreadable to the majority of severely deaf patients, e.g.

thi*nk*
i*ts*
rai*n*
*tak*e
get
we*t*
*h*avi*ng*
bee*n*
i*n*
be*d*
i*n*flue*nz*a

None of the consonants in italics can be identified in normal speech by lipreading alone. Context reveals them when they occur in words which are familiar.

It is improbable that any of them could be heard with the unaided ear by a severely deaf person.

to rain
like*ly*
ough*tn't*
to take
mac*kinto*shes
woul*dn't*
havi*ng*
in*flu*enza

In normal speech the syllables in italics would fall below the level of hearing of the unaided ear of a severely deaf person. Not one of them is wholly lipreadable by itself. The mind contributes such syllables when their context is known.

As a rule word inflexions are unstressed in English and the movements made in forming them are slight and very rapid. As would be expected therefore they present considerable difficulty to severely deaf children. This difficulty is more serious than appears at first. It limits the child's development of speech and English in two ways. He misses the

majority of unstressed words in sentences and thus his acquisition of vocabulary and of sentence construction suffers.

Unstressed words in sentences play an important part in linking ideas together. The finer shades of the meaning often depend upon the use of small unstressed words which act as connectives.

"I will go if you say so."

"Put it in your pocket."

"It has rolled into the corner."

"He and I are going there."

"We're going away for a few days."

Prepositions, conjunctions, relative pronouns, auxiliary verbs, short clauses and phrases are rarely stressed in English. These are the parts of sentences which are likely to escape the notice of severely deaf children. Their free written expression, which resembles broken English, confirms this analysis. If speech is to satisfy a deaf child as a ready means of expression of his thoughts, he must acquire a vocabulary of practically the same range as that required by a normal child in his home environment. Moreover, the deaf child must be able to express his thoughts in conventional sentence forms, otherwise he fails to make clear his meaning to normal people.

He resorts to gestures and signs when words fail him because of the urgency of his need for expression—but he would not resort to such measures if the words he wanted came as readily to his lips as gestures to his hands. There are always therefore two aspects of the development of language to be borne in mind by a teacher—the acquisition of vocabulary, and practice in sentence construction. Lessons given through the amplifier and lipreading, supported by reading, constitute the most valuable source of complete word and sentence patterns that can be given to a severely deaf child. He can learn words more quickly in this way, acquire a wider vocabulary and become familiar with conventional sentence construction in a relatively shorter time. Thus his acquisition of English and of knowledge is facilitated, but that is not the only advantage he gains by this method of learning. Every member of a class of severely

deaf children can take a fuller and a more natural part in lessons round the amplifier than is possible by lipreading or by any other means of verbal communication. The effect of hearing each other's voices seems to weld more closely the members of a class into a social group.

In the Junior school it is important to establish the use of simple sentences and questions. Daily lessons round the amplifier offer the quickest and most direct way of achieving this end. Stories, projects, experiences of all kinds are made the subject of the " amplifier " lesson. Story telling round the amplifier offers something new in the experience of severely deaf children. Their delight in stories is always very great, but it is enhanced by the sound of voice.

The reader is asked to imagine the story of the three bears told in words but without the dramatic touch which is given by the tone of Baby Bear's squeaky voice, Mother Bear's soothing tones and Father Bear's gruff growlings. The experience which is given to a severely deaf child who is enabled to hear and to appreciate for the first time the squeaky voice of Baby Bear and the growlings of his Father is not just a passing interest—it is an experience which will colour his imagination for the rest of his life.

Talkie films have supplanted silent films because the public finds a silent form of entertainment unnatural. Voice is like a thread which runs through most social relationships and which knits them closer together. In telling a story away from the amplifier, it is not possible for a teacher to make severely deaf pupils hear her voice. She cannot speak close into the ears of ten children at the same time, nor can she tell the whole story in a voice loud enough for their level of hearing when sitting at a distance that is suitable for lipreading.

Children in the junior school require the constant repetition of simple statements and questions. These can be offered most suitably through stories of every kind ; in this way a normal approach to history and geography can be made. A deaf child's mind must often seethe with unasked questions, and as yet there is no quicker way of encouraging them and of satisfying curiosity than through lessons round the amplifier. Throughout them all complete word and conventional sentence patterns used in conversation will be offered and expected from the child when he talks.

The words of dialogues, plays and the dramatic versions of stories can be practised with profit round the amplifier, each child learning and running through his part before dramatisation proper begins. The essential is that teaching which is given in speech and English without the help of a hearing-aid and that which is given with an aid should not be divorced. They should be correlated and associated in every possible way.

In the intermediate school one of the main needs of a severely deaf pupil is facility in expressing clearly more complex trains of thought, when one idea is dependent upon another. Reasons, conditions, causes are expressed in relation to activities, desires and experiences of all kinds. Hearing quickens the desire to talk and also the rate of learning new words and new knowledge. Lessons round the amplifier at this stage can take many different forms. Practically every different subject can be taken except handwork and physical training. History, geography, literature, scripture, nature study, elementary biology, mental arithmetic are all suitable subjects for amplifier lessons. With a blackboard and appropriate illustrations close at hand, methods of teaching can approach more nearly to those used in the education of normal children. The less severely deaf are enabled, at least for a few minutes at a time, to look at the blackboard or at an illustration while the teacher is explaining it. This is an immense advantage but one which is denied, of course, to the more severely deaf, who cannot follow the teacher's speech unless they combine lipreading and hearing all the time. But mental strain is lessened also for children in this group because an illustration can be looked at more intently and comfortably when the eyes do not need to glance continually from the picture to the teacher's face to see if she has begun to talk again. Her voice acts at least as a normal summons to attention even for the most severely deaf children. Experience in conventional sentence construction is offered in every lesson through the teacher's sentence patterns and the pupils' replies and contributions. Spoken expression at this stage involves the use of longer and more complicated sentences. These offer increased difficulty to lipreading, especially when the sentence involves the separation of the subject and predicate by intruding clauses which interfere with the main thought, as for example in the following sentence :

> A. " The boy, who was on his way home through the woods, suddenly saw a brown squirrel, which had a long bushy tail, scamper up a tree."

Sentence A, by lipreading alone, is much more difficult to follow than if the same information is given thus :

> B. " The boy was on his way home through the woods. Suddenly he saw a brown squirrel scamper up a tree. It had a long bushy tail."

Sentence A demands a longer span of attention. Its meaning cannot be grasped as a whole until the end of the sentence. The main thought is kept, as it were, dangling in the mind. In B there are the same three ideas but they are expressed separately. The span of attention for each one is short. Understanding of the whole comes from combining three simple and separate complete ideas.

Normally when we listen to complicated sentences, attention is kept alert and understanding is helped by the speaker's tone of voice, emphasis and phrasing. The particular value of teaching with a hearing-aid comes in here, for the severely deaf child can also get help, in quite a unique way, from the tone of voice, emphasis and phrasing. Thus in the intermediate school a hearing-aid is used to encourage and to strengthen the child's understanding and use of inflexions, correct verb forms, connecting words, phrases and more complex sentence constructions.

In the past grammatical teaching has occupied a prominent place in the curriculum of a school for the deaf because deaf children go short of so many thousand word patterns which the normal child hears without effort. The latter learns to talk grammatically by hearing the same forms over and over again, not through learning grammar. English lessons with the amplifier increase enormously the chances which a severely deaf child can be given of meeting the same words, forms and constructions again and again. It has already been shown that in this way he can be enabled to perceive many words which otherwise he would miss. In addition, time is saved and therefore he can cover more ground both in general knowledge and in English. Again, during this period all the speech and language which is taught away from the amplifier is consolidated by work done with the hearing-aid. The ideal plan is for a class

to use one for all English lessons apart from silent or written lessons. At present this is not practicable for all severely deaf children because of the expense of and the lack of equipment, but in the course of time happily it will surely come about in all schools for the deaf.

During the last two years of the severely deaf pupil's school career all teachers share a common aim. What the adolescent learns must be in the way of definite preparation for the change of environment that is about to come to him. On the one hand there is work and employment to be held in view, and on the other the boy's or girl's social relationships. The writers suggest that at this stage amplifiers be used to the maximum extent to promote and to encourage discussion in the class—discussion about every possible topic which is or should be of interest to the adolescent boy and girl.

Never before in the education of the severely deaf have there been opportunities for class discussions comparable to those which are now possible with an amplifier. Every such lesson at this stage should combine practice in speaking and in the use of English.

All the necessary teaching in English involved is strengthened by the use of the blackboard and by systematic teaching at other times away from the hearing-aid. There is no other way, so natural and so quick, of approaching the social side of the adolescent's development. He can be made more confident about his ability to speak, his power of expressing thought and his capacity to ask questions about matters which interest him. Confidence in these three directions is absolutely necessary if he is to retain or to improve the results of oral education after he leaves school.

It is generally acknowledged that if an oral pupil has before leaving school reached the stage at which he can use speech and language with pleasure and confidence, he will, when he revisits his school, be just as ready as formerly to discuss everyday topics and to enjoy talking. Sometimes his speech is more fluent and intelligible than when he was at school; sometimes the reverse, but the pleasure and satisfaction in speech remain. If an oral pupil does not experience satisfaction and confidence in speaking before he leaves school, his standard of speech and his use of it soon decline. When we meet him again it is heart-breaking to think of the many

hours he spent in learning to talk. Even so we believe that the hours were not wasted ; that the true value of oral education is not seen in the measure of success attained in speech ; but that it can only be judged in the light of general intelligence and of behaviour. The amplifier puts into our hands a way of bringing more of our pupils to the desired stage and of strengthening their permanent hold upon speech.

The results already obtained justify the claim that the combined means of lipreading and hearing act as a " speeding up " in the learning process. The need for careful, thorough teaching is as great as ever. There is nothing to be said for the " hit and miss " method of teaching with a hearing-aid, which is all too prevalent. In this method no tests of the children's hearing are made by the teacher ; an aid is purchased in the belief that it will do all that is needed even in the hands of some one who knows little or nothing about its output or how to use it ; no tests of the audibility or intelligibility of the teacher's speech are made ; she merely talks—and talks—into the microphone and the children listen—and listen— ; acts founded upon faith not upon knowledge !

We believe that more skill and more knowledge than ever before are necessary to the teacher who hopes to get the best results with a hearing-aid.

Technique in teaching with a hearing-aid may be defined as the efficient manipulation of the conditions under which the child learns and the teacher teaches. Some of the conditions obviously relate to lipreading, others to hearing. They include considerations about the classroom, the relative position of teacher and class, the management of the apparatus, the technique involved in " broadcasting " speech, and, fundamental to all, definite knowledge about each pupil's kind and degree of deafness. It is assumed that before beginning to teach with a hearing-aid, the teacher has made searching tests of the hearing of every pupil in her class. The results obtained with the unaided ear indicate the extent to which the child can (or cannot) use his hearing away from the amplifier and in everyday life.

The tests which the teacher makes of the child's hearing with the amplifier tell what he can be enabled to hear with that particular instrument. Results vary with different aids or possibly with different kinds of telephones, a fact to be

borne in mind when there are several different kinds of aids in a school.

For the purposes of lipreading, a classroom should be well and evenly lighted. When artificial lights are used it is an advantage to have lamps whose height can be adjusted by means of counterweights, and which are fitted with wide conical shades which direct the light evenly on to the face of a speaker, without dazzling the eyes of a lipreader.

The acoustic properties of the room should be good. Too much reverberation lessens the chances of hearing speech clearly through even the best aid. The classroom should be in a quiet place, free from the noise of traffic or other outside noises, which come through windows open for ventilation.

At the Royal Residential Schools for the Deaf, Manchester, two specially designed classrooms have been built [1] and equipped with hearing-aids. These rooms are proving most satisfactory in every way.

Seating arrangements should be comfortable. A pupil wearing headphones attached by leads to a central amplifier cannot move about very much and he is obliged to attend very closely during lessons. It is important therefore that all unnecessary strain or physical discomfort be avoided. The desks should be placed so that every child in the class is in a good position for lipreading. If the class forms a semicircle round the teacher as she sits in front of her microphone it is a good plan to let each pupil retain the same place for a definite period of about a week at a time and then move round by one place. This simple expedient gives every child in the class an opportunity to combine lipreading at different distances and from different angles (full face and side face) with hearing. The teacher talks within 1 foot of the microphone, which must not be allowed to hide her face from any child. When she is teaching she must bear in mind the distance at which she speaks from the microphone. The most complete word patterns are only given when the words are spoken directly into it. During voice and articulation practice she will therefore habitually speak or sing slowly and distinctly within 1 foot of the microphone.

In English or other forms of "language" lessons she can afford to speak a little further off, so long as she is using words

[1] In consultation with Dr. T. S. Littler.

with which the class is already familiar. When offering new vocabulary or new sentence forms she must again speak directly into the microphone.

A blackboard should stand close at hand behind but to the right of the teacher so that she can use it freely.

The teacher must know the output of the particular aid she uses. Her ear must be trained to listen critically to nonsense syllables through it and to assess the number and quality of vowels and consonants which are reproducible by the aid. The tests which she will find helpful require the assistance of another speaker so that :

(1) The teacher may not know what syllables are to be given in the tests when she is assessing the output of the apparatus.

(2) She should not receive the additional help to hearing which is given to her by bone conduction when she herself acts as the speaker.

A series of tests, such as those recommended in Appendix B and which include all the vowels and consonants in English, will quickly show the output of the aid. It is advisable that one person on the staff of a school be responsible for the upkeep of the hearing-aids and that they be examined daily to assure the best working conditions.

It is also desirable that each class teacher who uses the aid should listen to it critically for a moment before beginning to teach with it. A " check " test can be made by bringing a telephone to the microphone. A teacher soon learns to estimate the value of the " howl " which results. She must also see that headphones worn by the children are adjusted properly and that they are comfortable.

If the amplifier is equipped with individual volume controls the question arises as to how far the children themselves can set them to best advantage. When a child has or has had fairly good hearing capacity, he is, as a rule, capable of judging the level of loudness at which speech is most intelligible to him. This is not so for a severely deaf pupil. More often than not, he mistakes loudness for intelligibility. An unskilled listener cannot possibly judge his own capacity to hear, but the teacher, from the results of the tests she makes, quickly knows at what level of loudness a child hears best. In the first place, therefore, she should set the pupil's control knobs and teach him

how and where to set them according to his best hearing capacity in each ear.

At the end of a lesson and before another class uses the amplifier, all telephones should be sponged with disinfectant. Children with discharging ears should have their own telephones.

Coughs, shuffles, fidgetting or playing with leads all result in noise which comes through the amplifier and which mask the sound of speech and are therefore to be avoided.

The B.B.C. as a rule insists upon a rehearsal before a person is allowed to broadcast. The utmost care is taken by the speaker and by the engineer to attain the best standard of speech and reproduction respectively. It is not merely a matter of loudness. The quality and pitch of the voice, careful natural articulation of vowels and consonants, rate and rhythm of utterance are all responsible in part for the success of broadcast speech. A teacher who hopes to get the best results with a hearing-aid must therefore learn to broadcast speech and not merely to talk through a microphone. As a rule we speak more slowly to a foreigner, or on a bad telephone line, thus allowing more time for sound to be heard. This is needed also by the partially deaf listener whose interpretation of words and meaning is continually being delayed.

How often does one need to look at an unknown printed word for recognition again ? or to hear a completely new foreign name before it becomes part of one's vocabulary ? Most of us certainly need more than one presentation of the unfamiliar printed or spoken word. Repetition therefore constitutes an important part of the technique of teaching through a hearing-aid and lipreading.

Hearing and lipreading the parts of a new word for the first time may not straightway give a clear picture of the word as a whole, but with the second or third impression something definite often seems to happen and the word is born as an individual in the mind. It is almost like seeing the shadow of an object before seeing the object itself—the shadow prepares one for the object.

The writers do not like rules in teaching but they urge the following practice—that every new word or unfamiliar sentence construction be repeated twice through the microphone—then written on the blackboard and the whole sentence repeated again into the microphone. Such repetition is not as a rule necessary when familiar words and language only are being used.

CHAPTER XVI.

THE INTELLIGENCE AND EDUCATIONAL ATTAINMENT OF THE DEAF.

A. A BASIS OF INVESTIGATION.

This and the following chapter have been written with two distinct objects in view. The authors hope that they will be made more and not less interesting by a perfectly frank statement, at the beginning, about the nature of these objects.

The first is to invite the non-technical, as well as the professional, reader to look at the problems of deafness, and in particular the effects of deafness on the mind, through the eyes of psychologists and other research workers who have studied them.

Psychologists have already done so much for the non-ordinary child, especially for the sub-normal child, once the underdog of the school world.

They have defined backwardness and mental defect and so have provided a sure basis for the detection and special education of those who have less than normal powers. Some of us may recall in our own school-days certain boys or girls who were always at the bottom of the form. Neither they nor anyone else ever expected that they would do better. There they sat, educational failures, without hope during school hours.

For all such and for their parents a brighter day has dawned, when mental tests, school clinics, and child guidance clinics are becoming more and more widely accepted and used.

Unsuitable or ineffective education is not merely a waste of a pupil's time and of the parents' or the taxpayers' money ; there are further serious consequences. As Professor Burt has said : " Cases of delinquency or psycho-neurosis often occur in those whose mental level is not properly adjusted to the

requirements of their education—whose intelligence, therefore, is, in one direction or another, unequal to the difficulties and responsibilities of their daily work."[1] The child who can only benefit from a special form of education, adapted to his limitations, but who is not given it, often suffers a double injury. He misses the knowledge and training which his more normal school-fellows are gaining, and his experience of continual failure may build up in his mind an attitude of inferiority and defeatism and a permanent sense of injustice.

Few children, relatively speaking, actually become delinquents, through mis-education. Many more go through life wrongly adjusted and with an awareness of dissatisfaction deep down in their hearts, even though they may, in some cases, seek to hide it by an appearance of bravado or in other ways.

There can be no need to apologise for asking readers to think of the problems of deafness from the standpoint just described. Some children and some adults have been able to do without specialised training or any means of adjustment other than their own natural gifts, in spite of defects of hearing. The whole trend of modern psychology warns us to beware, however, that we do not allow any such to struggle unaided unless we are absolutely certain that their powers are equal to their difficulties.

Normal mental development and equipment depend, in the crucial years of early childhood, and to a considerable extent throughout life, upon the sense of hearing.

St. Simeon Stylites may have lived alone on his pillar to the good of his soul, but a healthy mind is not ordinarily to be found or expected in an isolated body.

There is no natural means of alleviating the mental effects of deafness which limits or prohibits free conversation. Most of the ways of alleviation are inevitably abnormal, deliberately thought out and artificial.

The second object of these chapters is to put clearly before parents, doctors, educational authorities and teachers, the results of a particular system of teaching the deaf—the hearing-lipreading method.

This system—described step by step throughout the book—has been evolved during a period of many years. It is not of

[1] Burt, Cyril, 1935, *The Sub-Normal Mind*, p. 37. Oxford University Press.

course in any sense fixed, it is always growing. Its first principle is to make use of any and every advantageous means that offers, or has been found in the past, mechanical or educative, to alleviate the otherwise cruel effects of incurable deafness.

Above all, it centres round the exploitation to the utmost, for the patient's sake, by training and with the help of the best mechanical aids, of whatever capacity to hear he may possess.

The word " cruel " in the paragraph above has been used deliberately. If deaf himself, or herself, the reader is unlikely to disagree. If neither deaf nor intimately acquainted with anyone deaf, the reader is still unlikely to disagree, after studying the evidence here offered, especially the records of boys and girls suffering from undetected deafness.

But, beyond anything else, the purpose of these chapters is to give hope, founded on facts and figures.

The diagnosis, " He is deaf: I fear no treatment will improve his hearing," does *not* slam, lock and bolt the door to the full development of a child's mental powers. They are a challenge to all concerned to begin at once a process of training and adjustment. It is the efficiency or otherwise of this educative process that opens or closes the door to ultimate happiness and to the life, in Carlyle's phrase " of a man living manlike."

In modern times a few men and women have so far triumphed over the handicap of deafness from birth or from early childhood that they have taken university degrees, on the same footing as normal students, and have won other distinctions.

Miss Helen Keller's [1] amazing career is one of those triumphs of the human spirit whose laurels will never fade. Blind and deaf, she lives a mental life which is richer than that of many of us who see and hear. This she has described, in her own characteristic style, in her books, perhaps most intimately in *Midstream*. Her teacher, the late Mrs. Macy, must rank as one of the great teachers of all time.

The honour of having produced Miss Keller and Mrs. Macy belongs to the United States of America. In England the higher education of the deaf began with Mr. A. Farrar,[2]

[1] Keller, Helen, 1929, *Midstream: My Later Life*. Hodder & Stoughton.

[2] Farrar, A., 1937, " My Story," *Volta Review*, **39**, 8, p. 443.

who became totally deaf from scarlet fever at 3 years of age. His success in the Cambridge Local Examination in 1876, just before his sixteenth birthday, attracted the attention of the then Prince of Wales, and subsequently he matriculated in the University of London.

Mr. Farrar afterwards rewrote and published the *Manual for Teachers*, originally prepared by his former teacher, the Rev. Thomas Arnold of Northampton. Mr. Farrar has since been responsible for the publication of translations of early Spanish books about the deaf, and has contributed articles or papers to various periodicals. He is also a fellow of the Royal Geological Society.

During recent years a born deaf student, educated at Cliftonville, Northampton, has taken a B.Sc. degree with honours at London University ; at Oxford a friend of the writers, who became totally deaf at 4 years, obtained a similar degree and has followed it up with a Ph.D. and a research appointment.

By contrast, when deafness has been undetected or unrecognised, and when, in consequence, the wrong kind of education has been given, we find such unhappy records as the following :

A girl of 13 years old was brought for tests. She had attended for some years an excellent private boarding school. Her reports said that she was far below her age in general attainments, but that nevertheless she appeared to be intelligent. Her speech was difficult to understand and her vocabulary was very limited.

Advice had been obtained from many quarters and was stated to be very conflicting. An otologist had diagnosed deafness but no steps had been taken to act on this conclusion. Another opinion was that her tongue was defective and that she should have an operation on it. A theory had been put forward that because, as a child, she had learnt a little Arabic, when living in Egypt, she moved her tongue differently from ordinary European folk and so found English difficult to learn.

When she had gained sufficient confidence this unfortunate patient began to tell a little about herself. Presently she burst into tears and said, "The girls at school say I am mad." It was clear that she was completely hopeless about herself and that her state of mind was utterably miserable.

An audiometer test of her hearing, in which she showed

herself a most careful and reliable subject, proved that she suffers from severe high-frequency deafness.[1] She hears voices, but speech, as it reaches her mind, is always muffled and indistinct.

The tragedy in this case was heightened by the fact that so far as the writers are aware, no measures were subsequently taken to educate her as a severely deaf girl.

Such instances may be infrequent but they are far from being unique. The whole modern technique of detecting, measuring and assessing the effects of defective hearing is a very recent growth. The discovery of children who have hitherto been believed to be mentally backward or defective, but who now turn out to be deaf, throws no aspersion whatever on the work of the past. It is a new step forward and does credit to the vigilance of the responsible authorities.

In an article recently published [2] the writers gave sample records of a number of children who were referred to them for hearing tests while attending elementary schools, private schools, and, in 13 cases, schools for backward or mentally defective children. Of the latter, 11 proved to be partially or severely deaf. They have since made excellent progress in a school for the deaf and they are known to have at least average intelligence.

Amongst 84 boys and girls of school age, who were tested later, and who were reported to be unsuccessful pupils in normal schools, or to be attending schools for backward children, 75 proved to be deaf. Of these 65 had defective speech, some being scarcely able to talk intelligibly at all. The other 9 children had defective speech but were not deaf.

It is a notable fact that they were sent by a relatively small number of medical officers, private doctors, and child guidance workers ; there must be many other children who have reached any age up to 14 years and yet are passing through their school life handicapped by chronic but undetected deafness.

This conclusion is supported by the recent finding in New York City, after gramophone audiometer tests of 774,576

[1] See Ewing, A. W. G., 1930, *Aphasia in Children*, p. 57. Oxford University Press.

[2] Ewing, I. R., and Ewing, A. W. G., 1936, " The Use of Hearing Aids in the Treatment of Defects of Hearing in Children," *Journal of Laryngology and Otology*, 51, 4, p. 1.

children, that $1\frac{1}{2}$ to $3\frac{1}{2}$ per cent. of the whole school population suffer from a significant defect of hearing.

There is thus a glaring contrast between the high achievement of a few deaf pupils, at the top end of the educational scale, and many histories of backwardness, where deaf children have been unsuitably taught, at the lower end.

The business of the psychologist is to analyse and to measure —to analyse the factors making for success or failure and to measure, at different stages in the lives of deaf children, the ill-effects of deafness and the benefits of right education.

The technique for making mental tests of deaf subjects is as yet in its beginnings. The information available for summary and discussion in these chapters is limited. That part which consists of original investigations reported by the writers is only tentative, and forms the prelude to a larger plan only just begun.

Nevertheless the knowledge already gained from the various investigations is believed to be of undoubted importance to all who are concerned with deafness.

The first investigation of the mental capacity of large numbers of deaf children was made in America rather more than twenty years ago by Professor Pintner and Dr. Paterson.[1]

The pioneer work of Alfred Binet and Theodore Simon,[2] in the early nineteen hundreds, had led to the widespread use, in the United States, of tests which involve asking the subject questions. Pintner and Paterson found themselves confronted, in schools for the deaf, with many children who could neither talk normally nor understand all that was said to them.

Concluding that a child, though deaf and dumb, may yet have good intelligence, they used a series of tests which could be given in pantomime without any talking at all.

These were called performance tests because in each, the child had to do something, in many cases fit puzzles together.

Some eleven years later a rather similar series of tests for deaf children was drawn up by Professor Drever and Dr. Collins of Edinburgh University.[3]

[1] Pintner, R., and Paterson, D. G., 1917, *A Scale of Performance Tests.* D. Appleton & Co.

[2] See Burt, Cyril, 1921, *Mental and Scholastic Tests.* King & Son Ltd.

[3] Drever, J., and Collins, M., 1928 (2nd edition, 1935), *Performance Tests of Intelligence.* Oliver & Boyd.

The authors of each of these series made use of a good deal of material that had been produced by earlier workers for various purposes, such as for testing the intelligence of recruits for the United States Army during the Great War.

Later, in this and the next chapter, appreciations and criticisms of these tests, as performance tests, will have to be quoted. Before that we need to fill in the background of more recent developments in mental testing.

There seem to have been in the past two ideas underlying the use of performance tests with deaf children. The first is, that if you cut out the use of words you measure something that is independent of schooling. Probably this is roughly true. It is not always so. Some instances are now being recorded at Manchester of deaf children who are obtaining scores normal for their age, after a period of attendance at a school for the deaf, but who only reached standards typical of mental defectives or of mentally backward children when tested earlier.

The second idea is that if you choose the right kinds of material for your series of performance tests and see that all your methods are technically correct, you measure something that is of very great general importance to the child, a kind of all-round, inherited capacity for mental development and for adapting himself to his surroundings.

This idea can no longer be accepted without qualification. Some of the more recent major developments in applied and educational psychology are quite at variance with it. The most valuable of these is perhaps what is known as vocational testing and guidance.

The object of this is to prevent the wastage that used to occur through square pegs finding their way into round holes. The procedure is to arrange with the National Institute of Industrial Psychology to make a study of the abilities that are needed in a particular kind of work and then to devise standard tests which can be given to candidates who wish to undertake it.

A member of a great industrial concern said quite lately to one of the writers, " Before we got the N.I.I.P. to make out these tests we used to have to sack a good many apprentices as unsuitable, now we don't."

A striking recent example of success obtained from the use

of psychological method was described in a report of the Industrial Health Research Board—" A Borstal Experiment in Vocational Guidance." [1]

The problem was the assignment of boys to work-parties for training in occupations ranging from those of fitter, plumber and blacksmith to gardener, farmer and labourer. It is not merely economical that the boys should be given a form of work in which they have the power to succeed. It is also essential to the rebuilding of character.

As a result of experiment it was found that 110 out of 158 boys selected for work-parties by a psychologist after test and personal study became Grade A (thoroughly satisfactory) workers. Of 160 boys who were selected for occupations by the house-masters (i.e. by the old method, without actual test) the number becoming Grade A workers was only 73.

In all this important modern work there is the recognition of the fact that different forms of work call for different kinds of ability. A rowing blue may also gain a double first at a University, but a professional football player is not by any means sure to make a good plumber, nor yet a successful barrister.

Dr. W. P. Alexander has made an important original investigation [2] of both the practice and fundamental theory of mental testing. His conclusions throw much light on problems about the mental effects of deafness. For this reason, and because it is impossible to do justice to Alexander's work in any other way, it will be quoted fairly freely.

The number of individuals tested was 300 (p. 40), divided into four groups. " First we took a (Scottish) school group of both sexes, as being perhaps the subjects on whom tests were used most frequently in educational guidance (e.g. for scholarship examination).

" Second, we selected a group of high-school boys as suitable to meet the needs in vocational guidance. In this case we must take account of the fact that high-school boys may have different experience that will be relevant in such a test programme.

[1] Rodger, A., 1937. H.M. Stationery Office.

[2] Alexander, W. P., 1935, " Intelligence, Concrete and Abstract ; a Study in Differential Traits," *British Journal of Psychology.* Monograph Supplement, 19. Cambridge University Press.

" To cover this we took two groups at this stage, one in a (New York) academic high school having had no practical training and a second one in a (Chicago) technical high school, all of whom had definite practical training.

" Lastly we took a group of (American) women all over the age of 16 and therefore, for purposes of intelligence testing, ranking as adults. These women were delinquents in a State institution. They were included because performance tests are frequently used in such institutions " (pp. 28-9).

The tests employed were as follows. Three tests of a performance kind were chosen. Two of these, the Kohs Block Design Test and the Cube Construction Test [1] had been used by Drever and Collins, but Alexander revised the method of scoring to allow of better discrimination amongst older subjects.

A third test, the Passalong Test (described by Alexander in the *British Journal of Psychology*, vol. xxiii, pp. 52-63, July 1st, 1932), consists of the transfer of a number of wooden blocks from one side of a box to the other without lifting them out of the box.

A number of verbal tests, including the Stanford-Binet, were used. " They all present a number of questions that can be answered by a word or a mark of some kind."

Three tests of mechanical aptitude were selected—" which could be given in group form and which were of a paper and pencil kind " (p. 47). One of these tests consisted of questions about a diagram of a weight suspended from a balanced rod. In another the subject was shown diagrams of complicated mechanisms, " involving wheels and pulleys and so on. Sometimes he has to make additions to the diagram to show how it could be made to function in a particular way " (p. 48). Additional tests were used with Groups 3 and 4 and in some individual cases.

Alexander's interpretation of the results of these tests (which he subjected to prolonged mathematical analysis) may be summarised as follows :

There are five factors making for success. The first of these he identifies as " g " and he refers to Spearman's conception of " g " as mental energy (p. 125). It is present in

[1] Tests of the puzzle type whose names describe their nature.

abilities of every kind, though not always very important in a particular situation.

In performance tests a new factor, named " F " by Alexander, which is independent of all other factors, always plays a part (p. 123).

By contrast " v," the verbal factor, is essential to verbal ability. " The practical man has high ' F ' along with his ' g,' while the verbal (academic) man has high ' v ' along with his ' g ' " (p. 124). The difference between practical and verbal ability is thus an absolute difference in nature, since " F " and " v " are wholly independent of each other.

Alexander seeks to correct the misconception that a man who is highly practical will inevitably be poor in academic work or vice versa. " A man may be very good in both spheres or very poor in both, or good in one and poor in the other."

The fourth factor, " X," is likewise independent and plays an important part in all school achievement. He suggests that it determines, to a considerable extent, interest in school work. He believes it to be a factor of personality and temperament, and suggests for it the name " persistence." Alexander says that " the person who has plenty of ' X ' is a ' sticker.' " Again it must be remembered that " X " is shown to be independent of other factors.

Factor " Z " is a second factor in character, of some importance in school achievement, especially mathematics, the number tests and English.

Success in English depends on three factors essentially " g," " v," and " X," the most important of these being " v " : the ratio is roughly, 1 " g," 6 " v," and 2 " X." Verbal intelligence tests alone are fairly reliable as a means of predicting success in English.

In the practical subject of shop-work, taken by the technical high school boys, the factors making for success were proved to be " X," " Z," " F," and " g " in that order of importance. The factor " v " played no part at all. Performance tests of intelligence were more reliable than verbal tests as a means of predicting capacity for this practical form of work.

The successful results in practice of educational and vocational guidance leave little or no room for doubt that its foundations are sound. If we believe them so, a number of conclusions about deafness follows.

Firstly, it is clear that we must not over-estimate the information which we can gain from giving performance tests to deaf children. Some performance tests can be proved to measure Spearman's factor " g," i.e. general intelligence or mental energy. Because this form of capacity is needed to a greater or lesser extent in all human activities, reliable performance tests are often useful in detecting mental deficiency or marked mental backwardness in children who are deaf or who are backward in talking.

The Drever and Collins performance tests of intelligence were recommended for this purpose in the 1935 Report of the Chief Medical Officer of the English Board of Education. Their use is advised by Dr. Cattell in his recent book on mental testing.[1]

Bearing in mind what has been reported earlier in this chapter, we may say that general mental energy and practical ability, which are what performance tests measure, are certainly less susceptible to the ill-effects of deafness than verbal activity, but that they are not altogether immune. An uneducated deaf child, whose performance test score is very poor, is not necessarily a mental defective.

The second conclusion to be drawn from the results of recent investigations of normal subjects must surely be that to study the capacity of deaf children for learning their native language, we need verbal or linguistic tests. Alexander found that the verbal factor " v " is six times as important as general mental energy " g," for success in English.

At this point we are obliged to take a further step. We find ourselves forced to think of the importance of verbal aptitude, both to the deaf child and to the adult who becomes deaf.

The adult is involved because success in lipreading or in interpreting imperfectly heard speech is impossible without familiarity with all the vocabulary and phraseology that may be used by a particular speaker in conversation.

Vocational guidance to the deaf.

Problems of vocational guidance of deaf pupils are also involved. Pioneer workers in the last century set themselves

[1] Cattell, R. B., 1936, *A Guide to Mental Testing*, p. 271. University of London Press.

the task of ensuring, as far as possible, the economic independence of deaf boys and girls on leaving school.

To a large extent they may be said to have succeeded. During the past thirty years the opportunities of deaf school-leavers to find employment have been greatly increased by the provision of manual training throughout the schools. Schemes of part-time training have been in operation in many schools, and at the Royal Schools for the Deaf, Manchester, and at the School for the Deaf and Dumb, Liverpool,[1] whole-time schemes are in operation after the age of 16 years.

Thanks to such training at school, and to the efforts of heads of schools and of missioners to the deaf, there were, even in the period of economic depression during which Dr. Eicholz prepared his report, only 7 out of 29 of the larger schools for the deaf with less than 60 per cent. of their school-leavers in employment.

The Manchester schools topped the list with 71 per cent. of all their school-leavers in employment, and 91 per cent. of pupils who had enjoyed vocational training had regular work.

These were encouraging figures, although with changing industrial conditions and greater use of machinery a period of crisis and increased difficulty for deaf school-leavers may lie ahead. But what of the principles upon which modern vocational guidance is based? Because a pupil is deaf it cannot necessarily follow that his natural bent is manual employment. There must be deaf boys and girls strong in verbal ability, " v," and less well-equipped with practical ability, " F."

Pintner [2] has just stated (at the time of writing) that one of his graduate students, Miss Stanton, has recently finished a careful study of the mechanical ability of the deaf. She finds the same wide individual differences among the deaf that are common among the hearing.

" Although one important aim in the education of the deaf must be vocational adjustment, we must realise that deaf children are no better endowed with mechanical ability than hearing children. We must not try to force them all into

[1] Eicholz, A., 1932, *A Study of the Deaf in England and Wales*, pp. 53-7. H.M. Stationery Office.

[2] Pintner, R., 1937, " Latest phases of psychological testing with the deaf," *American Annals of the Deaf*, **82**, 4, pp. 327-37.

occupations requiring mechanical expertness, an expertness that many of them seem destined never to attain."

Apart from private and unaided enterprise there is no provision for the higher education, in the sense of secondary education, of the deaf in Great Britain.

It may be objected that if there were such a secondary school, few deaf pupils would be fit to enter it. That, however, is surely a matter for inquiry. Unless we can state in facts and figures the reasons for the academic successes already gained by a few deaf pupils, we are not in a position to reach any conclusion.

In an article recently published in New York,[1] the writer attacks the problem on the broadest basis, including all those who suffer from defects of hearing. Quoting some successful cases he says, " When employers realise that defective hearing is often less of a handicap than defective technical knowledge, a new door of opportunity will be opened to our hard-of-hearing boys and girls."

It is at least possible that some born deaf and severely deaf boys and girls could also benefit from higher and technical education.

Language and thought.

To recognise that individual deaf patients must possess different traits, or kinds of ability, in different degrees, leads us still further. It is clear that to have, and to be educated to use, good verbal aptitude is invaluable to any one who is deprived of normal hearing. The deaf boot-repairer needs to read and write, and to communicate with his customers. That is a very poor minimum. To enjoy the opportunities which are now open to all, to be an intelligent citizen and to share the throbbing life of a modern social community, it is necessary to understand something of the constant changes that, in a complex civilisation, affect all its members. Personal contact, in free conversation, is the chief channel for this process of sharing new facts and new shades of opinion. Reading is only a supplementary means for the majority of people, and personal experience of events is strictly limited by time and place.

Ultimately, therefore, we are faced with the question of

[1] Katz, E. S., 1936, " Guiding the Hard-of-hearing : *Occupations*," *The Vocational Guidance Magazine*, 15, 1, pp. 10-14.

how far deafness, either from birth or contracted later in life, affects the processes of thought.

One of the writers had as a pupil a lady who, having been born totally deaf, had never been given any previous opportunities of education. She had lived apart from other deaf people and was forced to rely on spontaneous gesture as her sole means of communication. She did not know a word of English or of any other language. Remarkably enough she could play a good game of whist. Yet she did not know the names of the cards nor could she count by any ordinary means.

Apparently she had learned the game simply by watching others play. About the mental processes of such a patient we know, as yet, very little.

The mental development of a child who enters school, dumb at the age of 5 years, has taken place without the help of speech and all the vital help which speech gives to thought. We notice the outstanding characteristics of such a child's behaviour. Thought is apparently discontinuous, if we may judge from the flitting of his interest from one object of attention to another. Visual experience is proved to be important to him, when he shows that he has observed details which the normal child would almost certainly overlook. He has little power to anticipate future events.

Later, the born deaf child may learn, like Helen Keller, to describe in speech or writing, experiences which he had while he was dumb, but there is always then the certainty that he is telling of the speechless past in terms of his subsequent education and training.

Before speech is taught mental development must be taking place but on abnormal lines, and so also in the earlier years of schooling, unless and until the level of attainment in language taught at school is adequate to the boy or girl's needs in all the aspects of daily life.

There are two convincing sources of evidence that most normal thinking is intimately dependent upon proficiency in the use of one's native tongue.

The first is to be found in the study of speech development in young children who can hear.

Stern [1] has traced the way in which progress in learning

[1] Stern, W., 1924, *Psychology of Early Childhood*, p. 374. Allen & Unwin.

to talk leads to progress in mental development and vice versa. When he has learned to recognise and to remember the word "table," for instance, the young child has gained a symbol and a nucleus with which all his experience of all sorts of tables can become associated.

His knowledge of tables is acquired, in the first place, through the senses of sight, touch, possibly of smell and taste (if he licks the polish). The word is a kind of shorthand symbol, in which all his experience, and all that he may obtain second-hand through the conversation of others in the future, is gathered up. It is a much more efficient way of remembering than if the child were forced to rely on any less definite and less negotiable form of mental currency, such as recalled images of past experiences.

The second source is recorded observation of patients suffering from injuries to the brain. Sir Henry Head has summarised a mass of information about soldiers who, having received gun-shot wounds, suffered from defects of speech.[1]

He has described how these patients could not carry out correctly quite simple tasks, which at first sight seem independent of the use of words, such as imitating the movement of touching the right ear with the index finger of the left hand.

The present writers have had experience with sufferers from this form of trouble. An aphasic patient sometimes verbalises aloud while he tries to carry out the test. He may mislead himself by using the wrong words.

Special aptitudes may be needed by the deaf.

It was stated in Chapter X, that the speech of a large number of adult patients becomes imperfect as the result of chronic deafness. This is most markedly the case with patients who have become very deaf to sound heard by bone conduction and have therefore lost, wholly or almost wholly, the power to hear themselves talk.

The process of regression or deterioration in speech, through deafness, can be to a great extent prevented if the patient is trained to control his speech organs mainly through the sense of touch.

[1] Head, Sir Henry, 1924, *Aphasia and Kindred Disorders of Speech.* Cambridge University Press.

With the help of a trained teacher of the deaf, habits of correct speech can be made to depend on sensations of movement and position, muscular contraction, contacts of the tongue with the palate or teeth, and the like.

Normally we combine sensations from every possible source in order to control our movements. In walking, for example, we receive stimuli from "joints, muscles, tendons and other deep structures," as well as from touch spots and through pressure, as we place our feet on the ground, and as the contact of our clothes varies over different areas of skin. Yet these sensations of movement and position are not enough, for, as noted elsewhere, untaught young deaf children drag their feet. Hearing therefore as well as touch normally plays a part in walking.

To control the speech organs, without the guidance of hearing, is a special form of skill, which needs to be slowly and painstakingly taught and learnt. One or more special aptitudes may be needed for success in acquiring this form of skill. Possibly lipreading, and proficiency in following imperfectly heard speech, are similar instances, which may involve some common and some specific factors. Here is a field in which investigation may lead to useful educational guidance.

The reading ability of deaf children.

In the next chapter results are given of tests of the ability to read of deaf children, who have been taught speech.

Details will be quoted of the attainments at different ages of pupils whose first lessons in reading were given very soon after their first lesson in lipreading and speech.

The importance of reading to the deaf has been urged throughout the present book, as one of the ways of extending their contacts with other minds.

The deaf child, who like the pupils just mentioned, learns to read at the same time as he is learning to talk, is going through a different experience from the normal child, who learns to read *after* he has become able to talk quite freely.

This applies especially to reading aloud. To our deaf child, reading aloud offers more difficulty than to the hearing child, because, quite apart from whether he understands the sense of what he reads, he is using a form of motor skill, i.e.

control of the speech organs, which is still new to him, and which he must learn without the help of perfect hearing.

Modern methods of teaching the deaf take note of this fact. Lessons in reading aloud can be useful as a speech exercise, but the first reading lessons, and those which are most important at later stages are in silent reading, so that the pupil may concentrate his whole powers on gaining knowledge and satisfaction from the meaning of what he reads.

This consideration is vital in drawing up and assessing the results of tests of the linguistic attainment of deaf children, based on reading.

The suggestion has sometimes been made that deaf children could be educated mainly on a foundation of reading and less through lipreading and speech.

Against this there is the fact, that even in the child who has never heard there is a very direct instinctive urge to talk.

There is no similar inheritance of a direct instinct to read. So recently as 1900, thousands of people could neither read nor write. Reading, unsupported by a background of personal contact through speech, would be a cold-blooded business, without the emotional drive that language can only gain, in the first place, through its use as the living medium of intercourse of mind with mind, face to face.

CHAPTER XVII.

THE INTELLIGENCE AND EDUCATIONAL ATTAINMENT OF THE DEAF.

B. RESULTS OF TESTS.

THIS chapter falls into two sections :

(1) a summary of statistics obtained by tests of the intelligence and educational attainment of large groups of children, especially in the United States ; and

(2) records of intensive study of the progress of individual deaf pupils, educated with the help of hearing-aid apparatus designed by Littler.

(1) *Survey of schools for the deaf in the United States of America.*

The most important source of statistics about the intelligence and educational attainment of large numbers of deaf children is, at present, the report of the United States National Research Council, entitled " A Survey of American Schools for the Deaf," and published in 1928.[1]

In all, 4400 deaf children in attendance at 29 residential and 13 day schools were tested. The principal tests used were the Pintner Non-Language Mental Test, a method of measuring general intelligence without the use of words, and the Pintner Educational Survey Test, constructed from standard educational tests in use in hearing schools.

The educational test " attempts to give a general all-round measure of the basic elements in school, such as reading, arithmetic, and the like."

Both tests were carefully standardised with normal and with deaf children.

[1] The joint authors were Day, H. E., Fusfeld, I. S., and Pintner, R. It was issued by the National Research Council, Washington.

It was decided to test all children of the age of 12 years and upwards, regardless of the grades or classes in which they might be found.

The average age of admission to residential schools for the deaf was found to be 7 years, and to day schools 6 years. There were 1405 pupils over 16 years of age.

In the 29 residential schools 47 per cent. of the pupils were born deaf and in the 13 day schools 34·9 per cent. Four-fifths of 4856 children had become deaf before their fifth year.

More than 900 children amongst the 4400 who were given mental and educational tests had had some time in schools for the hearing. Almost one-third of these children—30·3 per cent.—had spent as much as five years, or even longer, in schools for hearing children.

A comparison between deaf and hearing children on the basis of the results of the non-language test led the investigators to the following conclusions.

In the abilities measured by the non-language test (from which the influence of capacity to talk and to use words in any shape or form was, as far as is possible, entirely excluded) the deaf children were from two to three years behind hearing children of the same age.

"The mean score of the 12-year-old deaf is 258, and this is about the mean for the 10-year-old hearing children; the mean for 13-year-old deaf is 276, about the mean for $10\frac{1}{2}$-year-old hearing; the mean for 14-year-old deaf is 300, about the mean for 11-year-old hearing; and the mean for 15-year-old deaf is 320, about the mean for 12-year-old hearing." [1]

The tendency of the deaf to be retarded was found therefore in each of these four age groups, and the gap between hearing and deaf tended to widen as the pupils grew older.

Precautions had been taken to ensure that the hearing children with whom the deaf were compared were not children of superior intelligence. In the 15-year-old hearing group elementary school children predominated.

In the educational test the backwardness of the deaf children, as compared with the hearing, was found to be considerably greater.

"We find that the 12-year-old deaf mean of 16 is not quite up to the 8-year-old hearing mean; the 13-year-old deaf

[1] P. 274 of the Report.

mean of 19 is just one point above the hearing 8-year-mean; the 14-year-old deaf mean of 23 is not quite up to the hearing 9-year-old mean; and the 15-year-old deaf mean of 27 is just equal to the 9-year-old hearing mean." [1]

The gist of the matter, therefore, is that the investigators found the deaf 4 to 6 years behind the hearing in educational attainment.

They also found that in the three years of school life, between the ages of 12 years and 15 years, the deaf children made only as much progress as the hearing children made in the single year from 8 to 9 years.

We may say that they found that American deaf children of 12 to 15 years old tended to remain at normal 8 to 9-year-old standards of educational attainment.

We may turn then with all the greater interest to the records which are given later in this chapter, of deaf pupils who have been found to pass this 8 to 9-year-old standard of attainment.

In their summary of conclusions the United States investigators ask whether the education of the deaf child would not be accelerated if it were begun at an earlier age. They suggest the establishment of nursery schools.

The wisdom of this policy has long been recognised by British workers. Wherever it has been adopted it has been justified by results. The first separate department in a British school, to which deaf children of 4 years old were admitted, was opened at the Royal Schools for the Deaf, Manchester, in 1912.

In 1937 an Act of Parliament was passed lowering the age at which the admission of deaf children to school becomes compulsory, from 7 years to 5 years. This step had long been urged by the National College of Teachers of the Deaf and the National Institute for the Deaf.

The present writers strongly recommend, in another chapter, methods of home-training for very young deaf children, from the time at which deafness is detected, even when it is suspected at the early age of 12 months.[2]

The American report also ends with such questions as these: "Could not reading be taught earlier and more efficiently than at present, so that the deaf children might get a better start with this basic tool? . . . Is the curriculum of

[1] Pp. 278-9 of the Report. [2] See Chapter VII.

the average school for the deaf developing in the light of modern curriculum research in the school for the hearing? . . ." [1]

Tests of deaf children by Drever and Collins.

In the second edition of their book, *Performance Tests of Intelligence*,[2] Drever and Collins give score and norms obtained by 1500 deaf and hearing children in various parts of Scotland and England.

Reference to these tests has already been made in the last chapter. The object was the measurement of general mental ability and the tests could be given entirely without the use of words.

The conclusions reached by Drever and Collins about the intelligence of deaf children vary considerably from those of the American investigation.

Drever and Collins found no significant backwardness, in ability as distinct from educational attainment, amongst deaf as compared with hearing children.

The causes of this difference in conclusions in the United States and in the Drever-Collins investigations have yet to be found.

(2) *Records of progress of individual pupils.*

The following are records of the educational attainment of 10 pupils. Of these, 7 (2 boys and 5 girls) have been taught individually by lipreading combined with the use of hearing-aid apparatus for long or short periods. Three children began their education by this method, at ages varying from $3\frac{1}{2}$ to $4\frac{1}{2}$ years.

Nine of the pupils are reported to have been born deaf and one became totally deaf at $8\frac{1}{2}$ years, following meningitis.

A. Tests.

Hearing.—Pure-tone audiometer tests were made of the hearing of all the pupils, in most cases at intervals during the period of teaching.

The Short Intelligibility Test of hearing for speech,[3] or the New Standard Testing Lists, or both of these, were given to eight pupils.

[1] Pp. 289 of the Report. [2] Published by Oliver & Boyd, 1935.
[3] Appendix B, p. 322.

Educational Attainment.

(*a*) Tests in reading, arithmetic, spelling and English composition were taken from Burt's *Mental and Scholastic Tests*[1] for hearing children. Of these tests Burt writes in his most recent book: " For the individual testing of scholastic attainments—more particularly with cases of backwardness or alleged mental deficiency—I venture to suggest the detailed series drawn up with the assistance of teachers in London. . . . Imperfect as such scales no doubt may be, they still remain, I believe, the only comprehensive system of school tests, as yet available for use in this country.

" The test-problems have been standardised by experimental application to more than 5000 normal children and 1500 mental defectives in London."[2]

For use with deaf pupils the attainment tests most readily used are:[3]

Test No. 4.—Reading (comprehension). The pupil is given in succession a series of cards on which directions are printed. He has to read each card to himself and do what it tells him. The directions become progressively more difficult and complex throughout the test.

Examples.

No. 1. (Age 5.) Get me a pen.

No. 9. (Age 7.) Take this card with you and do all that it tells you. First, go outside the room. While you are outside, change the card into your other hand, and then come back and put the card on the table.

No. 13. (Age 9.)

" The greenest buds of May,
The brightest flowers of June,
To me are never so gay,
As a brown October day,
With its golden sheaves
And its crimson leaves,
And Autumn tints of decay."

Which month does the writer think the most beautiful—May, October or June?

[1] First published as L.C.C. Report, No. 2052, 1921. P. S. King & Son.

[2] Burt, C., 1937, *The Backward Child,* p. 47. University of London Press Ltd.

[3] For the sake of readers to whom the tests are not easily accessible extracts are quoted by kind permission of their author.

The ages given in brackets are the average ages at which the London boys and girls reached this point in the test successfully; and there is also a more detailed method of scoring according to the total number of directions performed correctly.

Burt found this test most useful for "children varying in mental age from about 6·0 to 8·0 years; for children at the stage of Standard I—a standard which has perhaps the widest range of all—and above all, for older borderline defectives, such as are examined for possible retransference to an ordinary elementary school, this type of test is eminently adapted."[1]

Test No. 5. — Reading. (Continuous Prose, Comprehension.)

The pupil is asked to read aloud a paragraph from Ruskin's *King of the Golden River.* The following extracts show its character:

"On his way out of the town he had to pass the prison, and as he looked in at the windows, whom should he see but William himself peeping out of the bars, and looking very sad indeed. . . . Level lines of dewy mist lay stretched along the valley, out of which rose the massy mountains—their lower cliffs in pale grey shadow, hardly distinguishable from the floating vapour. . . ."

The pupil's understanding of the meaning of the passage is then tested by twenty questions which vary in difficulty.

Examples are:

Order of question.	Order of difficulty.	Question.	Answer.
4	1	Where was William?	In prison.
6	9	How did William reply?	He was very angry; or he gnashed his teeth; or he shook the bars.
13	5	What was he setting out to find?	The Golden River. (If the child replies "the river" or "the King," without being able to specify further, allow only ½ mark.)
19	16	Could he see the whole of the mountains very clearly? Why not?	No. Because of the mist (or shadow).

The questions are given orally to hearing children and they were given by lipreading with the help of an aid to the deaf

[1] *Mental and Scholastic Tests,* p. 276.

pupils under review. It is, of course, essential to keep scrupulously to the wording and procedure laid down by Burt.

Test 1.—Reading (Accuracy). Graded Vocabulary Test.

The pupil is asked to read aloud lists of words, graded in order of difficulty. The following are typical :

Age last birthday.	
4	to, is, of, at, he, my, up, or, no, an.
8	shelves, scramble, twisted, beware, commenced, scarcely, belief, steadiness, labourers, serious.
12	physician, fatigue, philosopher, melodrama, autobiography, constitutionally, champagne, encyclopædia, hypocritical, efficiency.

The ages quoted show, in effect, how far normal London children, of each age tested, could read correctly. E.g. At the age of $9\frac{1}{2}$ years about one-half of the children read correctly the words "money" to "already." Ordinarily the pupil is encouraged to attempt all the words he possibly can, and the total of those he has read correctly is counted as his score.

With deaf children who are being taught to speak, or who suffer from defects of speech, the motor aspect of reading aloud may become almost a predominating factor in this test. The investigator is also liable to experience difficulty in interpreting the child's speech if indistinct.

The best course seems to be to accept the pronunciation of a word if a given vowel or consonant is the nearest to normal of which he is known to be capable at the time of test. This, presumably, is what would have to be done in the case of local pronunciation amongst hearing children.

There is generally a clear dividing line, for deaf as for normal children, at which mistakes begin, and beyond which mistakes become steadily more frequent. Nevertheless, estimates of the accuracy of the speech of severely deaf children in such tests are much influenced by the investigator's previous experience and personal opinion. It will be necessary to return to this problem later.

Test 3.—Reading (Speed).

In this test the pupil is invited to read a list of monosyllables, e.g.

go	is	at	so	cat
mat	sun	has	boy	pen
oak	fog	air	vex	ark

A record is made of the total number of words that he reads correctly in sixty seconds.

In this test the problem of the intelligibility of the deaf child's speech to the investigator is not so likely to become acute.

The test may perhaps turn out to be a good rough guide to the degree of proficiency in control of the speech organs reached by deaf pupils. Certain features which are involved in reading connected speech, e.g. management of breath in phrasing and ability to say longer and more difficult words in sentences, are better measured in Test 5, the continuous prose test mentioned above. The total time taken by the pupil to read the whole passage aloud is noted.

Test 6.—Spelling ; and

Test 7.—Dictation.

The Spelling Test consists of words to be dictated by the investigator. The words are chosen on the same system as those in Reading Test No. 1. They become progressively more difficult and age norms are given for each group of 10 :

Age 5 :	a	it	cat	to	and
	the	on	up	if	box
Age 9 :	money	sugar	number	bright	ticket
	speak	yellow	doctor	sometimes	already
Age 14 :	virtuous	memoranda	glazier	circuit	precision
	mosquito	promiscuous	assassinate	embarrassing	tyrannous

The investigator is specifically forbidden to enshrine the words in a context. This test can reasonably be given only to deaf pupils who can follow speech with considerable accuracy by lipreading and a hearing-aid together, or who, if totally deaf, are exceedingly proficient in lipreading.

The dictation test, though difficult, is more manageable because it is arranged in short sentences, as a kind of story :

> " It is on a cat, but not a dog . . .
> I have asked forty girls
> this puzzle. None failed . . .
> Should your solution be
> satisfactory, I believe
> thoroughly acceptable
> prizes will be bestowed . . .
> pianos, sewing machines . . .
> excellent bicycles for picturesque adventure " . . . etc.

Arithmetic (Mental).

This test consists of 110 questions, which Burt tells us were intended to be given orally, although he allowed older children to write down their answers. Like Reading Test No. 1, they are graded in order of difficulty.

All the Arithmetic Tests are stated to have proved difficult to standardise but, approximately, it holds good that half of each series of ten problems could be answered correctly by normal London school children of a stated age. The whole test covers the ages from 4 to 14 years. A supplementary series of ten problems is provided for children below the educational age of 4 years.

Examples are :

Age 5 :

1. If you had 5 nuts and gave 1 away, how many would be left for yourself?

Age 7 :

3. How many ½d. stamps can I buy for 9d. ?

Age 10 :

3. I must be at the station a quarter of an hour before my train starts. It starts at five-and-twenty to one. When should I be there ?

Age 14 :

2. If a train goes 30 miles in $1\frac{1}{2}$ hours, how far will it travel in $4\frac{1}{4}$ hours ?

Arithmetic (Written Graded Test : Mechanical).

The order of difficulty of the sums in this test ranges from

Age 7 : 1.

$$\begin{array}{r} 21 \\ 37 \\ 18 \\ 36 \\ \hline \\ \hline\hline \end{array}$$

to Age 14 :

5. The area of a square is 1722·25 sq. ft. Find (in yards, feet and inches) the length of the side.

Arithmetic (Written Graded Test : Problems).

Examples are :

Age 7 :

5. Share one shilling equally among 6 children. How much would each have ?

Age 10 :

4. I have just bought 3 jars of raspberry jam at 1s. $1\frac{1}{2}$d. a jar ; $3\frac{1}{2}$ lbs. of butter at 1s. 2d. a lb. ; 5 lbs. of tea at 1s. 10d. a lb. ; 7 lbs. of sugar at $2\frac{1}{2}$d. per lb. How much have I left out of £2 ?

Age 13 :

2. If a frog spends 15 per cent. of its time in the water, and lives to the age of 16 years, how many days does it spend on land ?

Composition.

The pupil is given 30 minutes to write an essay, the standard subject being " School." The very interesting method adopted by Burt for assessing these essays will be described under the head of deaf pupils' achievements.

Midland Test 2 (*Cattell*).[1]

Vocabulary.

This test was given to 7 deaf pupils in all. Its author describes it as "A silent reading test to determine the size of vocabulary in respect of understanding the meaning of words seen (note that speaking vocabulary is smaller than the 'understood ' or reading vocabulary)."

With normal children it can be given either individually or as a group test to a number of children at once. It has been given individually to the deaf pupils.

The materials of this test are illustrated by the following :

6 *years.*

(1) A King is a $\begin{cases}\text{dog.}\\\text{man.}\\\text{flower.}\end{cases}$

(5) Newts are found in $\begin{cases}\text{fireplaces.}\\\text{pools.}\\\text{coal-mines.}\end{cases}$

7 *years* (·25 per question).

(6) Haste means the same as $\begin{cases}\text{flour.}\\\text{straw.}\\\text{hurry.}\end{cases}$

11 *years.*

(16) Candid means $\begin{cases}\text{sugary.}\\\text{frank.}\\\text{tinned.}\end{cases}$

13 *years.*

(18) A declivity is a $\begin{cases}\text{part of a ship.}\\\text{liking.}\\\text{slope.}\end{cases}$

[1] Cattell, R. B., 1936, *A Guide to Mental Testing*, p. 86. University of London Press.

The pupil is allowed 5 minutes for the test.

He is given a printed paper of the whole test and instructed to underline the correct word in each case.

For individual test scoring, when a child fails on three successive items he is considered to have stopped at the point at which he gave the last correct answer.

School subjects.

Progress in school subjects, Geography, History, Latin, Geometry, etc., is indicated by reference to achievement in test papers taken from public examinations, e.g. the Junior Cambridge Local Examination.

Speech.

It is clear that standard tests of the intelligibility of the speech of deaf pupils to listeners with normal hearing are needed. Tentative experiments with this object have been begun at Manchester, but in this book the writers prefer to give only analytic notes.

Intelligence.

The Drever and Collins "Performance Tests of Intelligence," which have been mentioned earlier, were given to nine deaf pupils :

Their nature is readily understood.

(1) *Kohs Block Design Test.*—Subject constructs, with coloured blocks, designs to match those represented on cards.
(2) *Knox Cube Test.*—Examiner taps, in varying order, cubes placed between himself and subject. Subject watches and imitates.
(3) *Domino Test.*—Examiner and subject each has a set of dominoes. Examiner exposes groups of dominoes for a limited time. Subject is required to reproduce the group he has seen.
(4) *Size and Weight Test.*
(5) *Manakin and Profile Test.*—This involves assembly, from parts supplied, of figures respectively of a man and of a human face.
(6) *Form Boards Test.*—A form of puzzle in which subject fits loose pieces into spaces cut out of wooden boards.

(7) *Cube Construction Test.*—Small cubes must be built to the pattern of a model supplied. Success depends chiefly on correct appreciation and use of painted and unpainted sides of small cubes.

(8) *Picture Completion Test.*—The first part of this, consisting of the insertion in a picture of star-shaped sections cut out from it, leads up to the second, Healy's Picture No. 1, showing ten separate events or activities. From fifty squares the subject is required to choose and insert ten, one for each event, representing the object most appropriate to it.

Two of these performance tests were used by Alexander [1] in the investigation described in Chapter XVI. They were No. 1, the Kohs Block Design Test, and No. 7, the Cube Construction Test.

He found that, in technical slang, they were "saturated with 'g'," i.e. that they give a good idea of the subject's general ability. He used a modified system of scoring.

Drever and Collins have not included in their book the scores obtained and norms for each test nor their correlations. No statement can be made about the abilities measured by some of the other tests.

The published norms of scores obtained on the whole series of tests are based on deaf and hearing subjects up to 16 years of age.

In the present investigation the Drever-Collins Performance Tests were sometimes used with older deaf subjects, as well as with those of 16 years of age and under, as giving useful information about their practical ability, and at least to some extent, their general intelligence.

Supplementary Test.

The Northumberland Mental Tests.

Since it is known that with normal children verbal tests are more highly "saturated with 'g'" than most non-verbal and performance tests,[2] Thomson's "Northumberland Mental

[1] Alexander, W. P., 1935, "Intelligence: Concrete and Abstract," *British Journal of Psychology Supplement.* Cambridge University Press.

[2] See, for instance, Cattell, R. B., 1936, *A Guide to Mental Training,* p. 3. University of London Press.

Tests " [1] were given to five deaf pupils, as being of an entirely different nature from any of the other tests used.

In these tests the child is provided with, first a practice sheet, and then a booklet, in which he has to write in blank spaces the answers to questions, or else to underline words which are themselves the correct answer.

The supervisor has nothing whatever to do beyond seeing that the children fill in their names, etc., correctly on the front page, telling them the time every quarter of an hour, and collecting the booklets at the end of 60 minutes.

The tests involve reasoning with verbal material. In No. 1, for example, Test A4 involves the grading of groups of words representing animals and numbers in order of size.

Part of Test B1 is, " Cross out plainly the ' extra ' word in each of the following lines :

charity,	kindness,	benevolence,	revenge,	love,
square,	circular,	oblong,	hexagonal,	triangular."

The child has already learnt, in the preliminary practice and earlier tests, that " extra " implies " not having the same qualities." In the first line the correct answer is, of course, " revenge," because its nature is opposed to " charity," "kindness," etc. Similarly in the second line, the child should underline the word " hexagonal."

No. 1 series of these tests was given to 2532 English hearing children in Northumberland elementary schools, aged $9\frac{1}{2}$ to $14\frac{1}{2}$ years ; No. 2 series to 13,625 children, aged 11 years 0 months to 12 years 11 months inclusive.

Results of tests of deaf children.

For practical reasons it was impossible to carry out all the individual tests above-mentioned with all the deaf pupils. The work had to be done at intervals over a period, and even to the older pupils it was not advisable to give, at the most, more than one hour of consecutive testing.

An effort was made to obtain the most complete picture of each pupil's attainments that could be had in the time available.

[1] Thomson, G. H., 1921, "The Northumberland Mental Tests," first published *British Journal of Psychology*, **12**, 3. Directions and forms obtainable from G. G. Harrap & Co. Ltd.

The pupils are assigned to two divisions :

(1) those whose education was begun by oral methods combined with ear-training ; and

(2) those who, after previous education elsewhere, were taught by oral methods combined with ear-training for a period of time, the length of which is stated in each case.

In each division one individual history is given first and is followed by a comparative summary and analysis.

(1) *Pupils whose education was begun by oral methods and ear-training.*

Pupil (*Philip*).

Cause of deafness. Born deaf.

Age at first test. $3\frac{1}{2}$ years.

Age at last test. 7 years.

Form of education.—Individual instruction, oral methods and use of hearing-aid for whole period, combined latterly with afternoon attendance at school for normal children for handwork, games and companionship.

History.—Healthy child. No serious illness. No history of deafness in family. Early diagnosis by otologist of bilateral deafness.

Walked at 18 months. Reported to enjoy banging piano keys.

Attainment when education begun.—Dumb, but had babbled and still used voice and "crooned to himself." Expressed wants and emotions by gesture. No understanding of speech. No ascertainable response to sound. Did not turn head nor blink for drum or large bell sounded behind head. No definite proof of capacity to hear was obtainable before the second six months of training by lipreading with a classroom aid.[1]

[1] Through this chapter the aids mentioned are of the classroom type designed by Dr. T. S. Littler with moving-coil or crystal telephones.

Audiogram (first made at 6 years old), better ear.

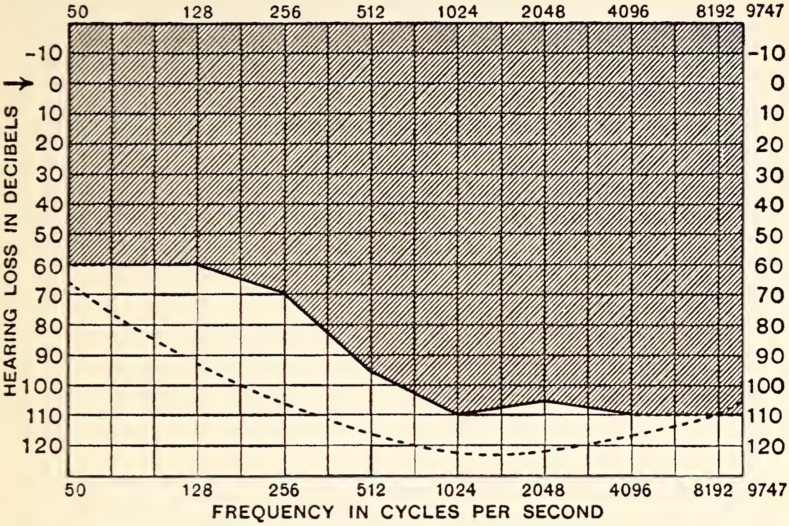


DIAGRAM 76.—Audiogram, left ear.

Right ear	128	256	512	1024	2048	4096
	70	80	105	110	110	110

Educational Attainment (at 7 years, after $3\frac{1}{2}$ years' teaching).
Hearing for Speech.—Short Intelligibility Test.

		Vowels.	*Consonants.*
Without lipreading	unaided hearing .	$\frac{0}{10}$	$\frac{0}{10}$
	with classroom aid	$\frac{6}{10}$	$\frac{4}{10}$

Reading.		*Score.*	*Age of hearing boys obtaining same score.*
Test 1.	Accuracy .	$\frac{31}{110}$	7 years
,, 3.	Speed . .	62 words in 60 seconds	8 ,,
,, 4.	Comprehension	$\frac{1}{17}$	5 ,, [1]
Spelling		$\frac{23}{100}$	7 ,,
Arithmetic (Mental) . .		$\frac{24}{100}$	6 ,,

[1] Philip at 7 years enjoys reading, unaided, books of simple stories and frequently asks for more to take home with him.

Composition.

Quality: Fully equal to median sample for 7-year-old hearing children.

Total number of words 52, equals achievement of normal hearing boys aged 7½ years.

Average number of words per sentence, 5·8, equals achievement of normal hearing boys aged 7½ years.

Philip wrote the following without help or preparation. It is entirely original and not a reproduction of any story he has been told or has read:

A story.

The boy [was] called John. One day John went out for a walk. He went to the shop. John came back home. John went out for a walk. He went to the Park. He saw a man [and] saw [a] woman and dog. The man was very cross. The dog bit the flowers.

Speech.—Quality of voice has never become monotonous like that of most children born severely or totally deaf. After 3½ years' training is able to imitate changes of pitch, by listening to teacher through hearing-aid apparatus, and to perform exercises planned for this purpose. Recites many simple poems fluently. At 7 years consonants more normal than vowels. Makes himself understood by speech to school friend with normal hearing.

Performance age.—Score at 7 years equals that of normal hearing aged 9-10 years.

Social adjustment.—At 7 years enjoys afternoon session at normal kindergarten school and has made a friend there with whom he converses by speech and, on his part, lipreading. The two boys pay visits to each other's homes.

Pupil (Nancy).

Recent audiogram (made at $8\frac{1}{2}$ years), better ear.

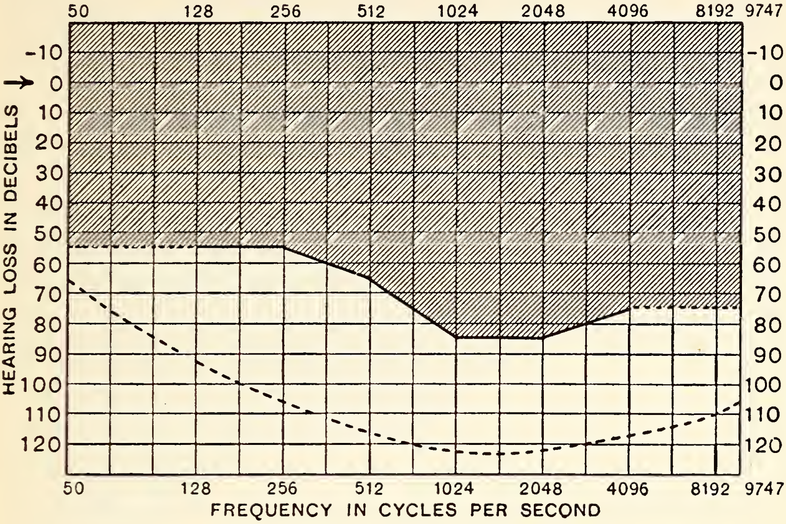


DIAGRAM 77.—Right ear.

Left ear	128	256	512	1024	2048	4096
	70	70	75	85	85	80

Intelligibility scores, per cent. (after $4\frac{1}{2}$ years' teaching).

New Standard Testing Lists.

	Without aid or lipreading.	With aid but without lipreading.	With both aid and lipreading.
Vowels .	0	95	95
Consonants .	0	50	86

Outline history.—Diagnosis at $3\frac{1}{2}$ years old of severe, possibly total, congenital deafness. No family history of deafness. Sister normal.

Before being taught, attempted to talk a little, used approximate words only and spoke in high-pitched voice. During five years' education, by hearing-lipreading method helped by much experience of hearing speech spoken close into her ear at home, interpretation of sound has steadily improved.

Her achievement in English composition at 8½ years is equal to that of average 9-year-old hearing girls in speed, and to that of 10-year-old hearing girls in length of sentences. She spends much time reading for pleasure, and enjoys books which are suitable for normal children of nine or ten.

Pupil (Henry).[1]

Audiogram (made at 11 years), better ear.

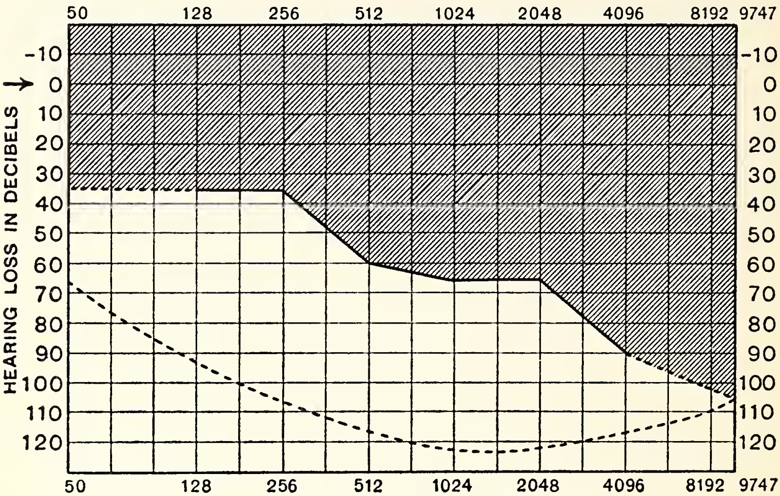


DIAGRAM 78.—Right ear.

Left ear	128	256	512	1024	2048	4096
	45	40	65	70	75	90

Hearing capacity for speech.

No opportunity for present standardised tests.

Compare patient no. 134 (p. 182) with similar hearing curve, whose scores in the Short Intelligibility Test are :

	Vowels.	*Consonants.*
Unaided ear . . .	$\frac{8}{10}$	$\frac{4}{10}$
With valve aid . . .	$\frac{9}{10}$	$\frac{7}{10}$

Outline history.—Appeared totally deaf to all form of sound at 4½ years and was dumb.

[1] For detailed history of this pupil see Ewing, A. W. G., 1930, *Aphasia in Children*, pp. 1-2 and 115-45. Oxford Medical Publications.

Education.—Individual, by oral methods and by teacher speaking within a few inches of his ear for period of 7 years. Afterwards attendance at normal school for handwork, games, companionship, and some lessons during latter part of that period.

In early stages speech and all use of language were acquired very slowly and with much careful effort, as by other deaf children.

At age of 12 years was able to go to normal preparatory school. From there proceeded to an English Public School. There has distinguished himself—at 17 years old was placed first in mathematics and second in French and Physics in a form of boys whose average age is greater than his own. His speech is now normal. Depends in class-work mainly on lipreading, but has excellent capacity for individual study.

Henry always read much for pleasure since he first became able at the age of 5 years to read the numbers of trams and tried to read the advertisements inside them.

Table of Attainments.

Three pupils taught by oral methods with aided hearing from an early age. Educational attainment given as age of normal hearing boys or girls obtaining same score.

Name.	Cause of deafness.	First test.		Most recent test.			
		Age when education began.	Attainment.	Chronological age.	Reading age (comprehension).	Arithmetic age (mental problems).	Performance age.
		years		years	years	years	years
Philip	born deaf	3½	dumb, no comprehension of speech	7	5	6	8-9
Nancy	born deaf	3½	a little very approximate speech	8	9	10	no test
Henry	born deaf	4½	dumb, no comprehension of speech	9	9	no test	13

Analysis of Attainments.

(1) After $4\frac{1}{2}$ years mainly individual education by the hearing-lipreading method, Nancy and Henry, though born severely deaf, had reached standards of educational attainment approximating to those of average hearing pupils of their own age. After $3\frac{1}{2}$ years of similar education, Philip, born almost totally deaf, was within 2 years of normal attainment in reading and within 1 year of normal attainment in arithmetic problems.

(2) The above statement is based on the form of reading test which deaf pupils have all, up to the present, found most difficult, namely, tests of comprehension through reading. In the graded vocabulary (accuracy) and the speed tests their scores are higher. (Similarly, in mechanical arithmetic deaf children almost invariably do better than in problems which involve a more complex use of words.)

(3) The general mental ability of all three children is above average, taking into consideration both their educational attainment and their performance ages.

(4) These three pupils suffer from the permanent handicap of having been born severely deaf. Their speech is the product of skilled individual education by experienced and highly trained teachers. It is not the result of natural development. All their capacity to use language has been acquired in the same way. Nevertheless a more than normal rate of progress has proved possible, with the regular, daily help of special hearing-aid apparatus.

(5) The hope is presented by these records, that with the daily use of the hearing-aid apparatus from an early age (in association with lipreading and always with specially trained teachers) severely deaf children may be helped to keep, at least in part, the natural quality of voice, which they always have in infancy, when they first begin to babble. It will be necessary to narrow down to the minimum the period of time between the cessation of babbling and the beginning of the use of hearing-aid apparatus in ways appropriate to young children.

Attainment and Intelligence of seven pupils, partly educated with the help of hearing-aid apparatus : summary of principal results.

(Attainment is given as age of normal hearing boys or girls obtaining the same score.)

Name.	Cause of deafness.	First test.		Most recent test.			
		Chronological age.	Attainment.	Chronological age.	Reading age.[1]	Arithmetic age.	Performance age.
Phyllis	born deaf	$9\frac{1}{2}$ years	very limited and imperfect speech : could read simple words and sentences	$15\frac{1}{2}$ years	11 years	11 years	$14\frac{1}{2}$ years
Mary .	born deaf	11 ,,	speech unintelligible and limited ; very little capacity to understand through reading	16 ,,	14 ,,	13 ,,	above 16 years[2]
John .	born deaf	16 ,,	little speech : reading age 7 years	17 ,,	9 ,,	8 ,,	above 16 years[2]
Charles	born deaf	14 ,,	had talked from age of $4\frac{1}{2}$ years, but limited vocabulary and grammatically incorrect	$19\frac{1}{2}$,,	above 14 years[3]	$13\frac{1}{2}$,,	above 16 years[2]
Rose .	born deaf	$18\frac{1}{2}$,,	speech careful although limited vocabulary ; reading age 8 years	$19\frac{1}{2}$,,	11 ,,	10 ,,	above 16 years[2]
Ada .	born deaf	$20\frac{1}{2}$,,	reading age 8 years	$21\frac{1}{2}$,,	9 ,,	10 ,,	no test
Molly .	became deaf after meningitis at $8\frac{1}{2}$ years	9 ,,	normal speech and reading	14 ,,	14 ,,	$12\frac{1}{2}$,,	above 16 years

[1] In this table reading age is the average for all reading tests : similarly in the case of arithmetic age.
[2] The highest norms available are those for 15-16 years.
[3] The highest norms available are for 14 years.

(2) *Attainment and intelligence of pupils educated for a time by the hearing-lipreading method.*

This section includes results of tests of 7 pupils, who have been taught by the hearing-lipreading method for short or long periods, but whose earlier education was given by other means.

Of these 7 pupils, 1 became totally deaf, after meningitis, at the age of 8½ years.

A summary of the results of the most important tests is contained in the table on page 291.

Hearing and Lipreading capacity.

Name: Phyllis.

Audiogram, better ear, air conduction :

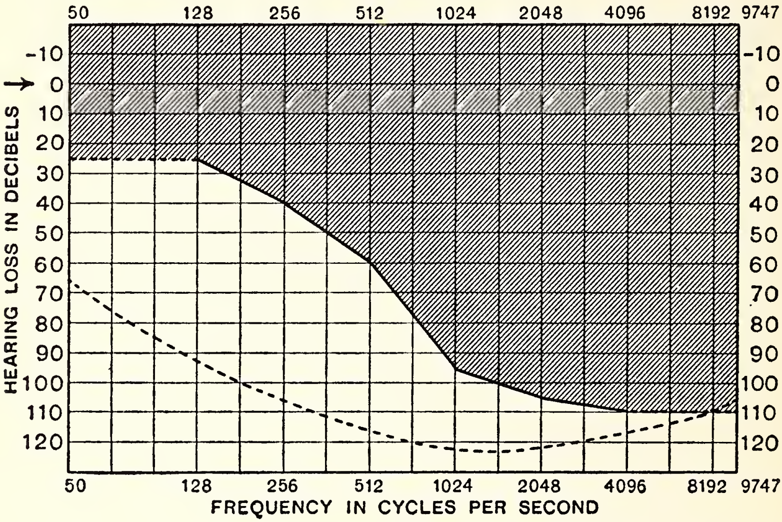


Diagram 79.—Left ear.

Right ear	128	256	512	1024	No response above 1024∼.
	30	35	80	110.	

Intelligibility Test Score, Per Cent., with New Standard Testing Lists, after Training.

	Without aid or lipreading.	With aid without lipreading.	With lipreading without aid.	With aid and lipreading.
Vowels	24	76	81	94
Consonants	7	46	66	86

Name : Mary.

Audiogram, better ear, air conduction :

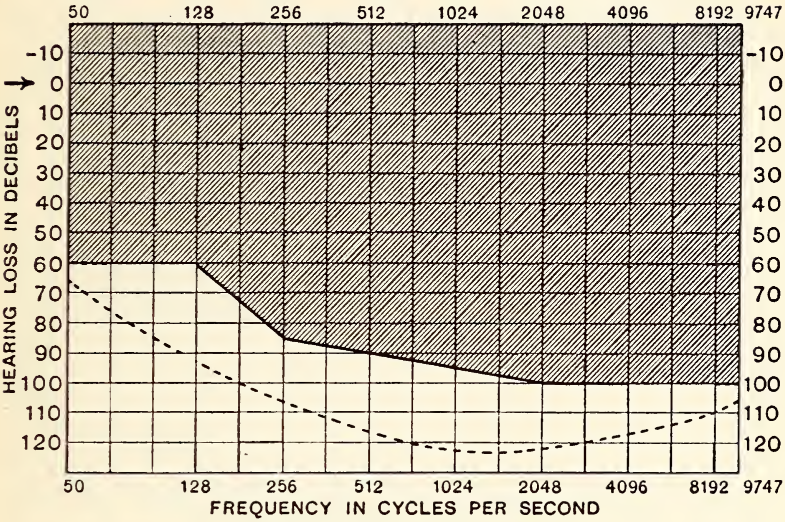


DIAGRAM 80.—Right ear.

Left ear	128	256	512	1024	2048	4096
	90	75	80	95	110	110

Intelligibility Test Score, Per Cent., with New Standard Testing Lists, after Training.

	Without aid or lipreading.	With aid without lipreading.	With lipreading without aid.	With aid and lipreading.
Vowels . .	0	27	73	82
Consonants . .	0	11	50	67

Name : John.

Audiogram, better ear, air conduction :

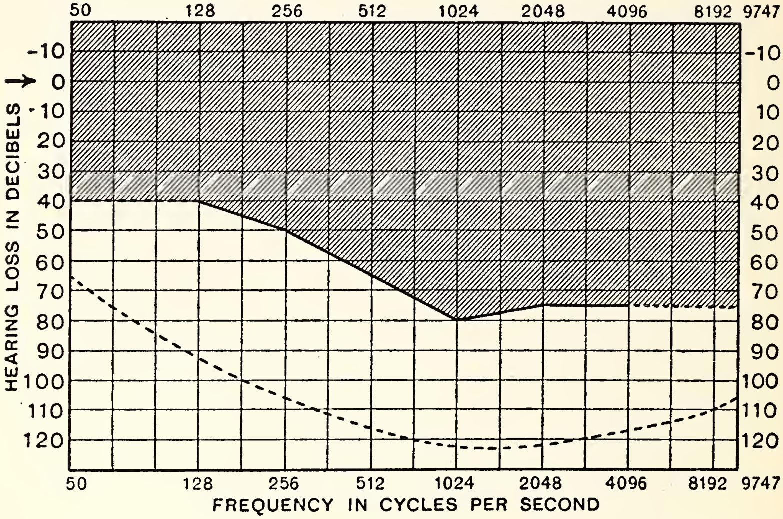


Diagram 81.—Right ear.

Left ear	128	256	512	1024	2048	4096
	40	50	70	90	85	75

Intelligibility Test Score, Per Cent., with New Standard Testing Lists, after Training.

	Without aid or lipreading.	With aid without lipreading.	With lipreading without aid.	With aid and lipreading.
Vowels . .	0	91	80	100
Consonants . .	0	65	41	74

Name : Charles.

Audiogram, better ear, air conduction :

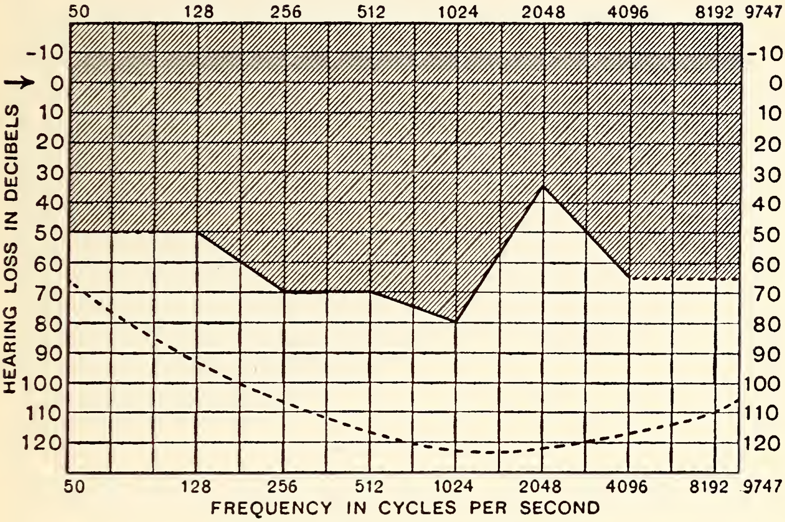


DIAGRAM 82.—Right ear.

Left ear	128	256	512	1024	2048	4096
	65	70	80	70	65	65

Intelligibility Test Score, Per Cent., with New Standard Testing Lists, after Training.

	Without aid or lipreading.	With aid without lipreading.	With lipreading without aid.	With aid and lipreading.
Vowels . .	48	100	100	100
Consonants . .	23	91	65	98

Name : Rose.

Audiogram, better ear, air conduction :

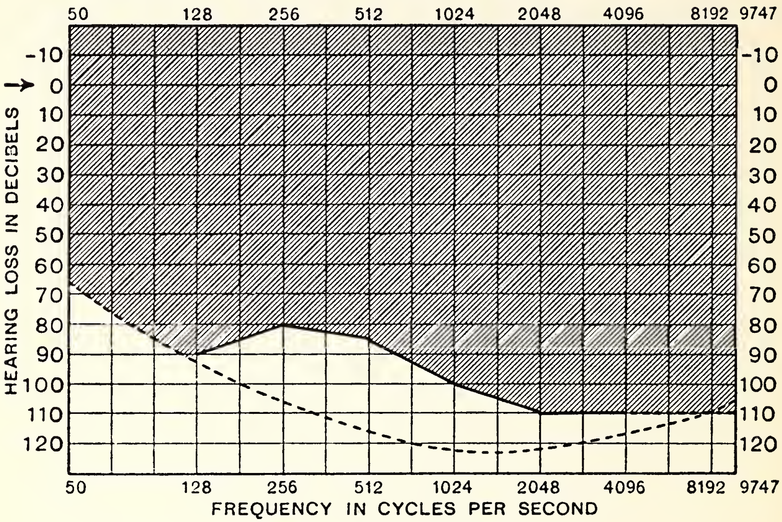


DIAGRAM 83.—Left ear.

Right ear	128	256	512	1024	No response above 1024~.
	85	100	95	105	

Use of hearing-aid was beneficial during speech and other lessons, but there was little, if any, ability to recognise vowels or consonants by hearing through the aid, without lipreading.

Name : Ada.

Audiogram, better ear, air conduction :

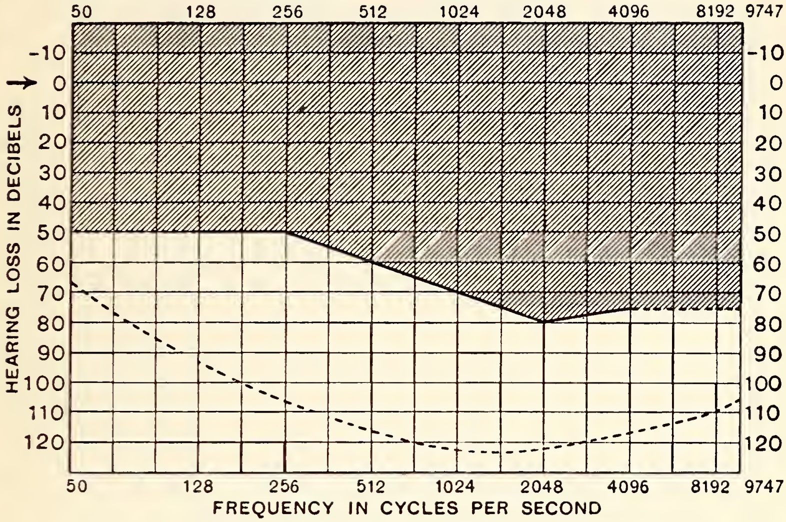


DIAGRAM 84.—Left ear.

Right ear	128	256	512	1024	2048	4096
	60	60	75	75	75	75

Intelligibility Score, Short Intelligibility Test, after Training.

	Vowels.	Consonants.
Unaided, without lipreading	$\frac{6}{10}$	$\frac{1}{10}$
With valve aid, without lipreading . . .	$\frac{10}{10}$	$\frac{5}{10}$

Name : Molly.

Total loss of hearing, after meningitis, at $8\frac{1}{2}$ years.

Intelligibility score, per cent., with New Standard Testing Lists, after 5 years' training.

	Lipreading only.
Vowels . . .	85
Consonants . .	44

Composition Test.

(Attainment given as age of normal hearing boys or girls achieving the same score.)

Name.	Chronological age.	Speed.	Quality (these ages are approximate).	Length of sentence.	List of connectives used.[1]
Phyllis . .	15½ years	above 14 years	12 years	10½ years	and 11, or 2, when 1, while 1
Mary . .	16 ,,	,, 14 ,,	13 ,,	above 14 years	and 24, but 1, or 1, then 2, so 2, because 2
John . .	17 ,,	,, 14 ,,	see note 2 below	7½ years	and 9, to 1, but 4, because 1
Charles . .	19½ ,,	,, 14 ,,	14 years [3]	above 14 years	and 14, but 3, while 1, for 2, if 1
Rose . .	19½ ,,	,, 14 ,,	11 ,,	10 years	and 8, or 3
Ada . .	21½ ,,	12 years	10 ,,	12 ,,[4]	when 1, and 11, or 1
Molly . .	14 ,,	12 ,,	13 ,,	above 14 years	and 6, or 1, except 1, then 1, when 2, as 1, so 2

[1] The number given after each connective shows how often it occurred in the pupil's composition.

[2] John's essay cannot be measured by normal standards. It describes a series of experiences in an emphatic and interesting manner. The arrangement of subjects is orderly but the expression is full of grammatical mistakes. It might sometimes be called fragmentary and might not be intelligible to the layman.

[3] Charles's essay is often adult in thought and expression but contains some errors of information and grammatical construction.

[4] Ada's sentences are longer than they would otherwise be because some of them are lists of objects.

Dictation Test.

(Attainment given as age of normal hearing boys or girls achieving the same result.)

Name.	Chronological age.	Dictation age.
Phyllis . .	15½ years	12½ years
Mary . .	16 „	12½ „
John . .	17 „	11 „
Charles .	19½ „	above 14 years
Rose . .	21½ „	11 years
Ada . .	21½ „	10 „
Molly . .	14 „	above 14 years

Midland Vocabulary Test.

(Attainment given as age of normal hearing boys or girls achieving the same result.)

Name.	Chronological age.	Vocabulary age.
Nancy . .	8 years	14 years
Phyllis . .	15½ „	10 „
Mary . .	16 „	10 „
John . .	17 „	9 „
Charles .	19½ „	14 years (no mistakes)
Ada . .	21½ „	9 years
Molly . .	14 „	14 years (no mistakes)

Northumberland Mental Tests.

Name.	Chronological age.	Series No. 1.		Series No. 2.	
		Score.	Mental age.	Score.	Mental age.
Phyllis .	15½ years	23	11½ years	42	13 years
Mary .	16 „	57	16 „	78	16 „
John .	17 „	31	12½ „	27	12 „
Charles .	19½ „	59	16 „	no test	no test
Molly .	14 „	54	15 „	81	16 „

Analysis of Individual Records.

Phyllis.—Born severely deaf. Some imperfect speech acquired naturally. Speech now fluent and accurate. Lipreading good.

Intelligence : 1 year below average hearing girls in performance tests, $2\frac{1}{2}$ years below in Northumberland Mental Tests, Series 2. Persevering temperament but learns slowly.

Educational attainment reflects this : Phyllis scores highest in dictation (3 years below) where attention and perhaps visual memory count high. She does less well in vocabulary, which she has to acquire mainly through lessons and reading. Arithmetic is a weak subject. A quiet girl of moderate ability.

Mary.—Born very severely deaf. All her speech has been taught. Speech now fluent but marred by early wrong habits of voice production. Lipreading good.

Intelligence : above average, equals average hearing girls in the Northumberland Mental Tests, Series 2.

Temperament : hasty, but interest readily aroused.

Educational attainment : after 5 years' teaching by oral methods with help of hearing-aid apparatus, she is 2 years behind average hearing girls in reading ability and 3 years in arithmetic. Arithmetic and dictation both affected by swift, rather hasty habits of mind. Vocabulary test score, 6 years below average hearing girls, shows that Mary has not yet compensated by adequate reading for limited opportunities of acquiring new vocabulary. In school subjects, such as geography, history and literature, where the necessary vocabulary is definitely taught, Mary is working satisfactorily to approximately a Junior Oxford Local standard.

John.—Born severely deaf. Scarcely any speech or comprehension of it after some years' attendance at normal schools.

Intelligence : clearly above average. With very limited equipment in understanding language, scores better in Northumberland Mental Tests than in Burt Scholastic Tests.

Temperament : persevering and sociable.

Educational attainment : after some years at normal schools was 9 years retarded. In 12 months education by oral methods with hearing-aid apparatus has advanced more than 1 year in reading and arithmetic.

All reading, vocabulary, and composition test results suggest high verbal ability.

Charles.—Born severely deaf, no speech until $4\frac{1}{2}$ years: at 14 years talked fluently but with high-pitched reedy voice and very limited vocabulary.

Intelligence: undoubtedly good, probably above average.

Temperament: independent, determined.

Educational attainment: particularly dependent on hearing speech through apparatus during lessons as weakness of sight prevents extensive or rapid reading.

His test scores are all above the highest available, i.e. for 14-year hearing boys, except in mechanical arithmetic. He makes no mistakes in the Midland Vocabulary Test. His standard of work in English literature, French, geography, history, Latin and mathematics is approximately that required for university matriculation. Some idiosyncrasies of thought and expression betray the fact that social and reading experience have been restricted.

Rose.—Born very severely deaf. All speech has been taught. Lipreading very good within the range of her vocabulary and experience.

Intelligence: good practical ability, performance score, $\frac{118}{136}$, is high.

Temperament: careful, persevering, likes little children.

Educational attainment: at beginning of year of education by the hearing-lipreading method reading age was 8 years, at end of year it was 11 years. No lack therefore of verbal ability. As result, became able to read simple books with pleasure; effects are evident in composition test.

Ada.—Born severely deaf. In first test, at age of $20\frac{1}{2}$ years, speech was imperfect and vocabulary very small. Voice was rough. Recognition of speech heard without lipreading was limited to numbers and familiar subjects and words. Was afraid of other than weak sounds when first began to use hearing-aid apparatus but through becoming accustomed to louder sound is now able to obtain more help from hearing-aid apparatus.

Intelligence: probably average, but good practical ability.

Temperament: impulsive, optimistic, naturally very sociable.

Educational attainment: her best achievement is in composition. This seems to reflect influence of temperament. Without special aptitude for language, is making progress by hearing-lipreading method at normal rate, despite very marked retardation at beginning of course.

Molly.—Normal life and experience to age of $8\frac{1}{2}$ years, then sudden total deafness after meningitis. At first test voice had already deteriorated to whisper.

Intelligence: considerably above average, achievement in Northumberland Mental Tests, Series 2, equals that of average hearing girls aged 16 years.

Temperament: immediately after meningitis and loss of hearing was anxious and hesitant: becoming increasingly more confident.

Educational attainment: as result of individual tuition is now equal to or above that of average hearing girls of own age except in arithmetic and composition. For long after her illness, arithmetic, in particular, showed inaccuracies typically found after meningitis. Similar errors occurred in written work in English subjects but have been less persistent in face of teaching. Handwriting still shows some of the marked irregularity that was evident directly after the onset of meningitis.

The number of pupils tested was too small to justify mathematical analysis of the results. The object of the investigation was to explore the problems by intimate personal studies of individuals.

Without unduly anticipating the results of an investigation of large groups of pupils, it seems justifiable to draw certain broad conclusions.

(1) *Method of teaching.*—All the ten pupils made considerable progress as the result of daily individual teaching by the hearing-lipreading method, regardless of age, ability and previous backwardness. It seems clear that the scientific training, by this method, of any power to hear that the pupil may possess, greatly facilitates educational progress because it increases the speed and accuracy of personal intercourse between teacher and taught. The case of John illustrates this fact almost as strikingly as the instances of Philip, Nancy and Henry.

Pintner found that American deaf boys and girls tended to make very slow progress after they had once reached a standard of educational attainment corresponding to that of average hearing children aged 8 years. Among the 7 pupils studied in the present investigation, 5 progressed much beyond this standard. Every one of the 10 pupils studied advanced at the rate of at least one year's educational attainment in a period of twelve months.

(2) *Age of beginning education.*—The three pupils, Philip, Nancy and Henry, whose education began at ages $3\frac{1}{2}$ to $4\frac{1}{2}$ years, approached more nearly to normal standards of educational attainment and mental development than those who were not taught by this method until a later age. It is undoubtedly true that twelve months' teaching by this method in early childhood, is more valuable than the same period of teaching in later childhood.

(3) *Methods of test.*—It is notable that all three of the youngest children learned, early in their education, to read much for pleasure. Nancy and Henry obtained normal scores, by the standards of average hearing children, in the reading comprehension test. This test seems to be a valuable means of measuring the deaf pupil's command of the tool most important of all to his education, namely, his comprehension of his native language.

The free and original composition test probably gives the best index of his development as a whole. The reproduction of a story which he has read or has been told by the teacher is not nearly so good a test, nor are his spoken and written expression in any subject in which he has had the chance of learning the relevant vocabulary.

His achievement in free composition usually falls much below his attainment in those ways. The following example illustrates the effects of deafness on mental development. It is an extract from an essay written by a deaf boy of 17 years (No. 134, p. 182). When first tested at that age he was found to be suffering from severe high-frequency deafness. He could follow speech, with the unaided ear, with any degree of accuracy only when uttered close to his head, yet the extent of his deafness had never been recognised. He had attended a public school as if he were a normal pupil. The consequence was that, although tests show that he has excellent ability, he

made poor progress. His reading and arithmetic and vocabulary age was 13 years. He wrote, for instance, that newts are found in coal-mines. His speech, though fluent, and superficially fairly normal, was mumbled and hesitant. His manner had become off-hand, perhaps rather aggressive. Some people thought him peculiar or at least rude. In spite of his ability he was at the bottom of his form during his last term at school.

In the composition test he wrote :

" School is said to be the home of the young boys, but these are divided up into two classes ; first the Day school and then the Boarding school. They only differ in two ways, one is that you live all the term at the boarding school and secondly the day-school has the shorter holidays. The most interesting part of a boarding school or at the one I was at, was the amount of spare time we were given everyday. Since I have only been at a day-school a short time, I cannot really tell you anything about them."

The reader will notice the inaccuracies of information and grammatical expression. There is also a certain vagueness in thought. " School " is not, as a point of fact " the home " of any boys, nor is it true that only " young boys " attend school.

This extract reflects in miniature the whole state of mind of such patients.

In a much lesser degree the same symptoms are to be found here and there in the essays of most of the pupils whose progress has been recorded in this chapter. Nancy and Henry alone have perhaps achieved the wide knowledge and social experience which are the only remedy.

In short, it may be said that the problem of the educational attainment of the deaf is primarily one of providing the fullest opportunities of direct personal contact between the pupils and normal people. The trained teacher must play the vital part. The use and training of hearing capacity are an invaluable aid. So also is wide reading necessary for the deaf pupil, though it must rank second to personal contact.

Above all, the key to the future lies in the beginning of education at the earliest possible age, by the most scientific means.

APPENDIX A.

VOCATIONAL TRAINING FOR THE DEAF.

BY JOHN SPALDING, HEADMASTER, ROYAL RESIDENTIAL SCHOOLS FOR THE DEAF, MANCHESTER.

THE writers of this book have given a very complete account of the modern system of educating deaf children, and have shown how the recent introduction of electrical amplifiers and hearing-aids into schools for the deaf have brought about new teaching methods, which ensure that full use is made of any hearing that may remain to a child and give promise of greater educational progress, particularly in the acquisition of speech and lipreading.

Nevertheless the fact remains that when his elementary education is finished, the child's organic defect—that of deafness—still remains. During his school life he has met many problems, but his greatest one faces him at the end of his school life. It is that of proving himself fit to take his place in the workaday world and to be able to obtain self-supporting employment and to achieve normal self-respecting citizenship.

Skilled teaching and scientific research have done all that is possible for the deaf child by the time he reaches the statutory school leaving age of 16 years, but henceforth his life is not to be lived in friendly competition with others who are afflicted in the same way as himself. He has now to prove himself in severe competition in industrial life with the hearing population. In many respects a lonely life lies ahead of him, and it can only be lived fully, and afford him satisfaction, if he is capable of suitable employment.

The success of his education is judged to a great extent by his ability to follow some trade or employment in a normal way and it is in great measure the duty of the school to prepare him for this. It is expected by parents and by Education Authorities and the deaf child himself completely depends upon it. It is a hard proposition, however, as his defect is permanent and he lives in an age of industrial machinery and an overcrowded labour market,

where employment is governed by numerous, if beneficial, Trades Board Regulations, Factory Acts, and Health, Compensation and Unemployment Insurance Acts.

To meet this modern industrial world the Government of the country has, following upon the Hadow Report, completely reorganised the system of elementary education for hearing children. Into the curriculum there has been introduced a practical bias which without prejudice to the general education of the pupils in any way, will make them better fitted to enter usefully into the various workshops and industries. This reorganisation should serve its purpose with normal children by providing industry with efficient workmen, but a much more definite preparation is necessary if all capable deaf children are to be successful in obtaining remunerative employment on leaving school.

In schools for the deaf the common practice is to speak of "hearing children" in differentiation from "deaf children." The general public, however, does not realise this kind of classification. It does not occur to the ordinary man in the street that there can be any but hearing children to think about. Consequently the educational reorganisation that is being made is for children in the bulk and deaf children do not figure in that consideration.

Furthermore, the industrial welfare of the deaf is only a very small part of the national problem, and employers who look to the schools for recruits to their workshops and factories do not, as a general rule, give it a thought. This may be unfortunate, as far as those who deal with the education of the deaf are concerned, but it is neither to be wondered at nor complained about. It has rather become the duty of the schools for the deaf to meet this condition of things and to see that everything possible is done by way of education and training for deaf children, to allow them to take their places in the industrial life of the country, and thereby to achieve responsible citizenship.

In these circumstances the vocational training of the deaf has of late years assumed an increased importance in the schemes of instruction framed by the various schools and education authorities. These bodies, encouraged by the Board of Education, have realised that if a child afflicted with deafness is to gain a satisfactory footing in industrial life he must receive some additional educational training during his school career. The result is that in most schools for the deaf special opportunities for trade training of some kind are arranged for their elder pupils. There is general agreement amongst teachers of the deaf that this is wise and necessary in the interests of their pupils. There is, however, a definite division of opinion amongst teachers of the deaf, education authorities, and welfare workers with the adult deaf as to when

such training should be given and at what age deaf children should finally leave the schools to enter industrial life. It will perhaps be useful, therefore, at this stage to outline briefly the various systems of trade training at present in operation in schools for the deaf.

In most schools this training takes place from the age of 12 or 13 to 16 years, when the statutory school age finishes for a deaf child.

The procedure in some schools is that half the day, from about 13 years onwards, should be spent in general elementary education and a half in vocational training. Training on this principle is carried out in well-equipped workshops at the Royal School for Deaf and Dumb Children, Margate, and at the London County Council's Residential Schools for the Deaf at Anerley and Oak Lodge. In other schools vocational training is given in the evenings, to avoid the necessity of taking away from general education any of the all too short time that is available for elementary attainments. A few of the smaller schools and the day schools are unable to arrange for definite trade training, but elder pupils are given regular handicraft training of a general kind, either in their own school or at a handicraft centre along with hearing children. At the Royal Residential Schools for the Deaf in Manchester, vocational training is provided for deaf students after 16 years of age. This principle was first put into practice with a few elder boys in 1905 and the scheme has been extended until there are now two modern residential schools and training workshops within the organisation which bear the names of their founders—The Sir James E. Jones Training School for fifty-two boys, and the Henry Worrall Training School for forty-two girls—where full-time trade training courses of three years' duration are available.

Since the establishment of this post-elementary training in trades, the Manchester schools have steadfastly set their face against attempting to train children in a trade during the elementary school period. Until 16 years of age the educational system is organised on the usual elementary lines, with special regard to manual training and art training as a preparation for future vocational training.

At 16 years of age the transfer from elementary education to vocational training takes place, and the vocational training courses are framed to cover a three years' period from 16 to 19 years. Although the statutory school leaving age for deaf children is 16 years of age, the Board of Education recognises these training courses under special regulations, and empowers local Education Authorities to maintain children from their areas in these training schools and allows the expenditure incurred to rank fully for grant purposes. During recent years the Liverpool School for the Deaf has adopted the Manchester system of trade training after elementary

school life, and the Royal School for Deaf and Dumb Children at Margate have extended their organisation so that boys may be retained, or admitted, after 16 years of age, for further trade training if necessary.

This explanation of the trade training systems at present in operation in the schools shows that a very strong attempt has been made to equip the deaf child for entry into industrial life.

Practically all the schools claim a satisfactory measure of success with their trainees. Those which give general handwork training prior to 16 years of age claim that a child is able to enter any skilled industry where his manual dexterity will entitle him to a training under workshop conditions, in any of the numerous available trades. Those where definite part-time training in a trade is provided argue that the child is in a better potential position industrially if he leaves school at 16 years of age with this training and enters the trade in which he has been trained straightaway, and that he has a better chance of being absorbed in his trade at that age than he would have later.

The Manchester schools take the view that to begin with any trade training during the elementary school life of deaf children must be a compromise, that either the elementary education cannot be as full as it might be if trade instruction was eliminated from its sphere, or the training in a specific trade cannot be as complete and thorough as it would be if such training took place after elementary school life.

The point is advanced strongly that, even if it is admitted that part-time trade training has been a real advantage to the deaf, it is doubtful if it is sound educational practice to devote any elementary school time to training of this kind. The hearing child is assured of an educational period when thoughts of specific trade training are not considered, and the deaf child, whose elementary education is a far more difficult problem, is entitled to the same consideration, and that twelve or thirteen years of age is too young, in these days, for a child to begin to receive trade training. The records of these schools show that no great difficulty is experienced in placing well-trained young men and women at work in their trades on leaving at 19 years of age, and it is contended that this trade training of the deaf is better in the hands of instructors who understand them and that the chances of blind-alley employment are thereby considerably reduced.

Fifty years ago good craftsmen were produced by apprenticeship and all large and small industries had their full quota of apprentices, but times have changed and also methods of production, so that at the present time the opportunity of apprenticeship is available for only a small number of children on leaving school.

Practically the whole of the deaf population have to live by the work of their hands, and the task of fitting them into the great industrial machine must, generally speaking, be a special job devolving on those who, through intimate knowledge, are interested in their problem. The greater proportion of the deaf children who pass through the schools are capable and worthy of being absorbed in industry. It is very doubtful, however, if in these days it is possible for the deaf child to choose the trade he would like best, and the training provided in the schools so far is for those trades which they can do as well, or better than, hearing children. So far all the educational establishments seem to have concentrated, in their various ways, on the same trades. In the Manchester Schools the trades in which instruction is given are : at the Sir James E. Jones School for Boys—bootmaking, tailoring, joinery and cabinet making, and baking and confectionery. At the Henry Worrall Training School for Girls : dressmaking and needlework, and laundrywork and fine ironing. The same trades are taught at other schools where training is provided.

A much greater variety of trades in which the various schools could give instruction would be a distinct advantage : this limitation of trades is a handicap. At the same time it must be remembered that a training school is an educational—not a commercial—concern, and that the bulk of the work, whereby training is provided, must be found within the organisation of the school itself, as the commercial disposal of goods is a difficult and delicate problem. It is certain that in the trades outlined the deaf do become skilled and capable workers ; but there are undoubtedly many other trades in the country at which deaf children can do well if they can obtain an entry into them and be assured of a sound training when they are in them.

One thing is certain—charitable industry for the deaf is nowadays no longer practical politics. Present-day employers will only employ deaf persons if they are capable of doing jobs as well as, or better than, their hearing brothers. The satisfactory solution of their industrial problem can only be achieved by full and complete training in some skilled trade either in a trade training school or a factory workshop. The competition with the large hearing population is too severe to be trifled with, and if casual employment is to be avoided it is necessary that no capable deaf child should leave school without having received a full trade training while there, or alternatively with an assurance that a thorough training is available for him outside. If the 80 to 85 per cent. of capable pupils in schools for the deaf are to be fitted not only to obtain employment in skilled trades, but to be found good enough to retain such employment, it is necessary that this

good industrial material should be shaped by well regulated conditions of elementary and vocational training, so that it may not only be developed to the utmost but given a fair chance of success in a crowded labour market.

A brief outline has been given to show what is being done in schools for the deaf to solve the industrial problem. It may now be useful, as the writer is conversant particularly with the vocational training carried out in the Manchester Schools for the Deaf, to describe in more detail the Manchester system of vocational training.

In the first place, there is no dividing line between elementary education and vocational training. The one gradually prepares for and finally merges into the other. The fact is always kept in view that successful vocational training depends largely upon a thorough elementary education, and it is never out of mind that the salvation of a deaf child from an industrial standpoint must in most cases finally be a skilled trade. The definite objective of a handicraft trade is, therefore, always kept in view for all the capable pupils. In nearly all deaf children there is an intense desire to acquire manipulative skill, and this distinct manifestation is encouraged and fostered by strong manual and art departments in the elementary sides of the school work from the very earliest stages onwards.

Particular attention is given to physical fitness. The young deaf person of poor physique has no chance in industry to-day, and if he is not physically fit, considering the one permanent defect under which he labours, his entry into trade is well nigh impossible. In addition to this every effort is made to build up in the pupils, from the very first, a strong sense of self-reliance. Young children in the junior school are trained to go up a side street alone to the shops and letter-box. There are no locked doors, and no general embargo on freedom of going out into the streets, and to shops, and even into the city, by pupils of ten and eleven years of age and upwards ; there are no apron strings in any department of the schools. The alert hearing child is always kept in mind as a pattern, and every effort is made to stop the dragging of feet and to smarten up the general bearing of the pupils, so that they should not suffer by comparison with hearing children in briskness, alertness and practical common sense.

All these points help a deaf child finally to secure a foothold on the threshold of industry. With this end in view the work of the elementary departments of the schools is as practical as possible. Without omitting the higher ideals of a good general education, it has been realised that the hearing child probably learns more of his mother-tongue out of school than in it, and also in finding his

way about, in being useful, and in reckoning up his prospects in life. This is always taken as something to be aimed at apart from routine classroom teaching.

The manual and art departments are looked upon as the beginning places for handwork skill, and are intensely interesting and valuable from every industrial standpoint. A great deal, too, is learned from the industrial training departments as to what is required from the elementary school—in addition to general smartness and reliance, the ability to use a footrule accurately, to read and understand simple written and spoken directions with certainty, to follow and make plans to scale and measurement and to understand costs, realise waste, and know all about materials.

These, then, are the general guiding principles followed in preparing deaf children at the Manchester school for trade training. Except, perhaps, in slight detail, they are those followed in all up-to-date schools for the deaf in their efforts to fit their children to take their place in life.

The statutory school life of a deaf child is at present completed at 16 years of age and entry into the Vocational Training Schools at Manchester is, therefore, optional. Four distinct partners take an active part in these training schemes—they are the local education authority, the trade training school, the parents and the students, and none of them are allowed to be sleeping partners.

The procedure followed is that when a pupil in the elementary department is approaching 16 years of age the parents are consulted. If they are satisfied that suitable employment is straightaway available for their child then all is well and there is nothing more for the schools to do but wish him success. Unfortunately such employment is apt to be suitable as far as the child's capacity to perform it is concerned, but unsuitable in ensuring a real training in a skilled trade and proving lasting in character. The chairman of one of the largest education committees in the country has just stated that " Half of the City's first year workers change their jobs. The main factor is that there are so many short-lived jobs, such as those of messengers and handy lads for the child leaving school. The fact that some of the new light industries employ much juvenile labour, and offer only seasonal occupation, has added to the problem. For very many years there have been more unemployed between the age of 16 and 18 than between 14 and 16."

Anyone who has studied the problem realises that this is a statement of fact, and it can readily be understood how difficult it is for the untrained deaf child of 16 years of age to secure a permanent foothold in industry, with a guarantee of a real training in a skilled trade, when so many hearing children of the same age are coming out of employment. It has also to be remembered that a deaf

youth cannot move easily from one job to another, and that the real danger to him is future blind-alley employment and intermittent casual labour.

If, however, no employment is available and the parents desire further training the particular trade, of those available, for which the child appears suitable is decided upon. The pupil's inclination is naturally taken into account so that he is not put to an occupation for which he has no liking.

Having settled on the trade, the pupil is transferred for a short trial period before he is 16 years of age. If this trial is satisfactory and the child gives promise of making good, then the responsible education authority is recommended to extend its responsibility for a further three years so that full trade training may be carried out. When this agreement between the schools and the responsible education authority has been reached, the student, on completion of his elementary school period, makes his final entry into full trade training. About 70 per cent. of the elementary school leavers proceed to the trade training schools, and students from other schools for the deaf are also admitted at 16 years of age.

The value of these training courses is appreciated by the Board of Education and the local education authorities, who are always ready to give their financial support in the maintenance of students when they are recommended so to do. The great desire is to prevent a deaf child leaving school untrained and entering some employment by which he can earn a few shillings a week, but which will probably terminate in a year or two and provide no real training.

The writer has in mind two boys who have recently left the schools ; both very intelligent, capable youths. The first left at 16 years of age and obtained employment as a handy boy in a drug store. The second, after three years training in the baking and confectionery department of the training school, left at 19 years of age and started work at his trade with a reliable and well-established firm. In the ordinary way it is not difficult to visualise these two men at say thirty years of age. The latter with a skilled trade at his finger-tips should, with attention to his job, be in regular employment at his trade. The former starting in a job which ensures no training in a skilled trade, will possibly have moved from one type of work to another and be dependent on casual and unskilled work. Educators of the deaf generally, who have studied this industrial question, are agreed that the final salvation of a deaf child is a skilled trade.

If trade training in school is to be done at all, however, it must be done well. At the outset it is a costly procedure and its success depends upon a few definite factors.

In the first place, adequate and modern workshops must be

provided and equipped with up-to-date machinery, so that ordinary workshop conditions may be maintained. In a bootmaking shop electrically driven finishing, soling, cutting, and patching machines need to be installed. A baking department needs modern ovens, electric mixers and so on. A laundry department requires electrically driven calenders, washing machines, ironing machines and drying apparatus. Similarly, in any trade training department modern machinery, such as is used in the industry, must be installed. To give the deaf boy or girl a chance of ultimate success at his work he must be trained on machinery, and under conditions, such as he will meet when he finally leaves the training school and takes his place in the world.

Again, only a large school for the deaf is able to organise efficiently post-elementary trade training departments, as the majority of the students must be drawn from the school's own elementary departments and the bulk of the work must be provided by the school itself. Trade training schools cannot be run as businesses on unlimited orders accepted from outside sources, nor can goods that are made be disposed of commercially through retail shops and their sale advertised. Trades unions and local craftsmen would at once raise a reasonable objection. It is obvious, however, that unless a continuous supply of work is available training in any trade cannot proceed. This necessity makes the provision of organised trade training in a small school for the deaf out of the question.

Most important of all, skilled and intelligent instructors must be secured. In trade training, as in all teaching, the deciding factor is the teacher. Modern buildings and adequate equipment will not solve the problem unless capable expert instructors are available. An instructor in a trade training department for the deaf needs to be a dual personality. In addition to being a teacher, with a real desire for this side of his work, he must be an expert craftsman at his trade. This is a combination which is not easy to come by. It is not difficult to obtain the good teacher who is a poor craftsman, and it is easy to secure an expert craftsman who has no knowledge of teaching and lacks any understanding of educational principles. The school is fortunate that can secure for its trade training departments the right type of teacher-craftsman. Technical instruction has become much more general of recent years, however, and qualified teachers employed in this type of work are assured of the same financial consideration as teachers of other subjects. A supply of more skilled and capable instructors has therefore been forthcoming of late.

When adequate workshops, up-to-date equipment, and efficient instructors have been secured there still remains a good deal to be

done to ensure sound vocational training for the deaf. Industry has become highly specialised and needs to be studied. It is necessary to discover what is required for success in the various trades, such as division of labour, passing work at various stages from one worker to another. This is team work and is found in all large and fairly large businesses. It must be applied in the training department, as it is only in the small shops of a few hands that entirely individual work is carried out.

The training, consequently, must be varied, in order that the deaf student may ultimately have a better opportunity of obtaining employment with either large or small firms. Some apprentices are slower than others and each one has to be considered from the final standpoint of weekly wages or piece-work. Again, the possibilities of a student's ability to run his own business has always to be kept in mind. A number of ex-students who are deaf, from the Manchester Training Schools, have found that, after a year or two in industry, they can do better by running their own small businesses. This is a successful possibility in trades like dressmaking and boot-repairing, where the intial outlay is not great and only a small amount of apparatus and equipment is required in the first instance.

Contact with the industrial side of the trades they are learning must also be provided for students. Regular visits to typical business firms need to be arranged where all the processes of particular trades can be seen in stages. In this manner the importance of fitting in with some particular stage of work can be explained and the interest of the students can be aroused and stimulated in a way that is not possible in any trade training school by itself.

In connection with the Trade Training Department of the Manchester schools regular visits of this type are arranged. Joinery students visit timber yards and cabinet-making works. Baking students visit flour mills and large modern bakeries ; and senior students from this branch are affiliated for special work to the baking and confectionery department of the Manchester College of Technology. Bootmaking students visit modern tanneries, large boot-repairing firms, and the bootmaking section of the Leeds College of Technology. Visits of a similar kind, allied to the trade they are learning, are arranged for students in the other departments. This method of bringing clearly to the minds of students what will be expected of them when they eventually become wage earners is invaluable, and with the willing co-operation of outside firms it is a system that can be constantly developed.

It is an advantage, too, to bring deaf students, whenever opportunity arises, into direct competition with hearing persons of their own age engaged in learning the same trade. This has been done very successfully in the Manchester Schools. Students from the

dressmaking department have gained numerous first-class certificates and distinctions, in competition with hearing girls of the same age, in the dressmaking examinations held by the Union of Lancashire and Cheshire Institutes. Prizes, medals and diplomas have been gained by students from the baking and bootmaking departments at trade shows and exhibitions and at the Manchester College of Technology in direct competition with hearing candidates. Such competition helps the deaf worker to realise, and take pride in the fact, that at the job he is doing he is quite as capable as his hearing brother.

The programme in the trade training school should also be based on actual workshop hours. Times should be strictly kept and workshop routine carried out. It is also essential that some of the theoretical side of the trade should be taught to students. This is done in the evenings in the Manchester schools so that no time need be taken from the practical training. The various instructors conduct classes in drafting and pattern drawing, etc. The art master holds classes in applied design and clay and wax modelling, and teachers from the elementary departments give instruction in book-keeping, business letter writing, buying of material, selling prices, insurances, etc.

This summarises the main essentials for the trade training of the deaf in a post-elementary training school. The steps followed are quite clear. First there is the full elementary preparation without filching any time from that most important stage. Next comes the choice of trade, and trial period at it. This is followed by active practical and real training for a career which leads in turn to direct entry into work from the Trade Training School. Such a scheme makes it possible for deaf students to be turned out as good wage-earning craftsmen, in some cases capable of setting up and carrying on successfully businesses for themselves. While they are receiving such training they are also being helped over the very difficult time of adolescence by people who thoroughly understand them, and their characters are being developed and strengthened in every way. A large stock of organised experience is constantly available to help these young deaf men and women to acquire backbone and to develop that kind of self-respect which grows through work well done.

When the question of the provision of suitable trade training for the deaf is under consideration it has to be remembered that two minorities and one majority in regard to the classification of deaf children are being dealt with—10 per cent. very intelligent and 10 per cent. backward—at each end of the scale—and 80 per cent. average in the middle. Handicraft industry is open to all but the backward. The small backward group are unfitted for training in the skilled trades and it is unwise to let them enter

workshops under false pretences. The result is disastrous for themselves and reacts unfairly on the really capable skilled deaf worker. They are usually capable of unskilled employment but cannot be trained to the degree necessary for success in industry.

Careful discrimination, therefore, is required in regard to fitness, and attention must be given throughout school life to the discovery of aptitudes so that the suitable deaf child should finally receive training in a trade for which he is suited. A clear distinction, too, should be made between the ordinary school-room tests and those applied to determine fitness for any particular kind of work. It is in the more practical sides of a deaf child's education—where he is learning by doing—that special aptitudes will show themselves. It is much easier, the modern industrial world being what it is, to name the unsuitable trades for a deaf child than the definitely suitable. All this means that successful vocational training for the deaf depends greatly on successful classification in their elementary school life ; and classification to the ordinary man in the street means finding out what a child can do. Very few deaf children are too backward to be capable of useful manual work. Encouragement and the demonstration of a teacher's belief in a child's ability to do a job, even though he is a backward child, means that he will begin to do it and his self-respect will start to grow and it will go on growing.

For the small majority of backward deaf children, then, the general elementary education should be as practical as possible. On account of being mentally backward, having defective eyesight, or suffering from any other physical affliction, they cannot be trained for successful entry into the skilled trades.

This does not mean that the small percentage of deaf children of this type are totally unemployable. In most cases they are capable after school life of doing unskilled work. The girls can be usefully employed in routine domestic work and the boys in outdoor labouring work of various kinds. They are quite capable of mowing lawns, tidying flower-beds, keeping paths clean and tidy, and doing general work of that kind. When it is realised how solitary and soul-destroying the lack of employment is to a deaf person of this type, one is inclined to think that local authorities could do a great deal by employing the small number of such school leavers in their areas in their public parks, gardens and institutions on routine work of an unskilled nature.

Much more consideration in the future needs to be given, on the other hand, to the welfare of the small percentage of highly-intelligent deaf children already mentioned. There is no doubt that their abilities entitle them to a much fuller educational life than the grant-aided schools are at present able to provide. With greater educational facilities, too, they would, without doubt,

prove themselves fully capable of following occupations of a higher technical standard than those in which training is given at present in vocational training schools. A few such children have proceeded from the Manchester schools to schools of art and colleges of domestic science. A small number of intelligent boys have been indentured to dentists and trained as dental mechanics. These are following successful careers, and undoubtedly other schools for the deaf can point to a few particularly intelligent children who have proceeded to further training in a specialised subject and subsequently to a satisfying occupation.

The problem bristles with difficulties, however, both educational and economic. There is so far in the country no secondary school for deaf children and no special technical training for them in the higher crafts or professions. The authorities of the various schools have to think of their children as a whole and are not able to provide facilities for the odd child. Without continual specialised assistance, too, it is almost impossible for a highly intelligent deaf pupil to proceed, with hearing pupils, to the ordinary secondary schools, technical colleges and universities.

Very vital, too, is the economic difficulty. It has to be remembered that practically all the deaf children in the state-aided schools come from homes where it is essential that the deaf member of the family should after school life be capable and practically assured of self-supporting employment. The fact that many deaf children proceed at 16 years of age to blind-alley employment is often due to the fact that they must be able as soon as possible to contribute to the family budget. During the deaf child's school life, if he is in a residential school, his family have to pay a maintenance allowance to the local education authority, and it is a double relief to the working class family when this payment ceases and the child, no matter how intelligent he may be, can add his share to the family's weekly income.

Nevertheless there is universal concern amongst educators of the deaf that so far there is no special avenue along which their brilliant children can pass to higher education in the purely academic sense and finally to technical college and university life. The parents cannot afford it even with the usual scholarship assistance. It would be much more costly than in the case of hearing children and it is doubtful if local education authorities would feel justified in providing it. The only hope at present seems to be that private benevolence will eventually enable something more to be done for the small group of deaf children who are capable of much further educational advancement than they achieve at present.

The writer has tried to show in a brief way what the difficulties are regarding the employment of deaf children when they leave

school, and has outlined the various ways in which the schools, by their vocational training schemes, have attempted to solve the difficulties. He himself is firmly convinced, after a quarter of a century's experience in teaching deaf children, that the deaf child, like the hearing child, is entitled to a full elementary period of education and that definite vocational training on all grounds should be post-elementary in character.

One thing is certain—no deaf child should be allowed to leave school without being as fully equipped as possible, by education and training, to take his place in the industrial world as a skilled worker, if his abilities can enable him to acquire such skill, and that his place in the industrial world should be that for which his abilities qualify him and not that to which his deafness condemns him.

Before this, perhaps somewhat idealistic condition, can be achieved it will be necessary for the statutory responsibility of the State for the education and training of the deaf to be extended for three or four years beyond the present statutory age. Along the lines of the Hadow recommendations for hearing children, there could then be a break at the end of the elementary school period which would have been devoted entirely to elementary attainments and not to training in a trade. After the break, and on leaving the elementary deaf school, capable children would need to be placed in outside workshops for supervised training or transferred to trade training schools. This would be the responsibility of the local education authorities who would need to assure themselves throughout of the satisfactory nature of the training. On completion of training of whatever kind the responsibility of placing the deaf worker in employment at his trade would fall on the Mission for the Adult Deaf or the local education authority, preferably on a combined committee of the two bodies.

In such a scheme as this, provision could be made, as far as possible, for the placing of the small educationally backward group in unskilled employment of which they are capable, while the highly intelligent group—the cream of the elementary schools—by means of scholarship and generous subsistence allowances could be enabled to proceed to secondary school education and finally, if warranted, to technical college and university training.

The education of the deaf is costly, and any extension of the present facilities would prove still more costly, but in the long run it would prove worth while and ensure a better return to the State on the money expended. The trained deaf are a national asset and the cost of such training is a sound national investment. Furthermore, the great proportion of children who pass through the special schools for the deaf are worthy of every educational advantage that can be provided for them, and ultimately of finding a place in the industry of the country.

APPENDIX B.

THE SHORT INTELLIGIBILITY TEST.

USES OF INTELLIGIBILITY TESTS.

THE test given below has been found effective for estimating :

(*a*) the relative ability of different deaf listeners to hear and recognise vowel and consonant sounds ;
(*b*) the extent to which an individual deaf patient or pupil is helped by a particular hearing-aid ; and
(*c*) the efficiency of a hearing-aid when used by the same person on different occasions.

Characteristics and limitations of simplified tests.

Intelligibility tests for clinic or for daily classroom use must be short. When they are to be given to inexperienced or young deaf listeners they need also to be very simple.

It is usually best for the examiner to test each patient separately and for the latter to repeat aloud what he hears. Spelling difficulties are liable to be introduced if patients are asked to write what they hear. Imperfections in their speech, due to deafness, often contribute to the need for a simple form of test.

The use of standardised sentences or phrases has proved unsatisfactory for several reasons. For school use, when a number of children are to be tested on many different occasions, it is impossible to provide a large enough number of sentences to avoid repetition and learning due to practice. Sentences which have become familiar can be recognised even though very incompletely heard. With normal listeners it has been found by Bell Telephone Laboratories that only 30 per cent. vowels and consonants need to be heard to give a 90 per cent. score on sentences. In general it is impossible to ensure that sentences shall be of equal difficulty to patients of different ages, whose range of vocabulary, standards of education, and previous experience, may vary greatly.

Vowel sounds and simple consonant and vowel combinations measure with a valuable degree of accuracy the listener's ability

to recognise the elements of which speech consists with a minimum amount of help from context—the object of such tests being to evaluate auditory efficiency and not intelligence or ability to understand his native language.

A warning must be given, however, about the interpretation of the results of short and simple tests. The following series of simplified tests are a reliable means of comparing auditory efficiency, but because simple they are insufficiently searching to form a basis for the absolute determination of speech intelligibility. In other words, the scores are higher than can be obtained with the longer and more complex standard testing lists. A consonant score of 90 per cent. or over in the simplified tests indicates that speech is heard accurately enough for familiar subjects and language to be understood. It does not necessarily imply that every consonant is heard distinctly or that in a school for the deaf every consonant can, in the conditions of the test, be taught to a deaf pupil without recourse to sight and touch. A consonant score below 50 per cent., even though accompanied by a vowel score of 100 per cent., shows that as far as the conditions of the test are concerned, speech as heard by a deaf patient is often unintelligible without the help of lipreading. In such cases, however, ability to hear voice tones only, may become a valuable aid to lipreading and to the development of speech in deaf children.

Procedure.

Conditions may of course be varied according to the purpose for which the tests are being used. In general it is most important to know a deaf patient's ability to hear speech under two conditions :

(1) when listening with the unaided ear to speech uttered in an mf. to f. voice at a distance of 36 inches from his head ; this, in the case of the born deaf child, involves his ability to learn to talk through hearing the conversation of others without an aid, and
(2) when listening through a hearing-aid with speech amplified to what for him constitutes the optimum level of loudness. (This level is usually 90 to 110 phons.)

The possibility of help from lipreading must be excluded during the test proper. Most careful control is necessary of the loudness of the examiner's voice. This is best brought about by employing a standardised amplifier equipped with an output-meter to record the intensity of the examiner's utterance.[1] A uniform loudness

[1] The Department of Education of the Deaf, Manchester University, is prepared to give technical advice.

level of approximately 65 phons for all tests has proved most satisfactory. Where no mechanical help is available the examiner may obtain approximately reliable results by practising carefully with a number of reliable deaf listeners until repetitions of the test with the same listeners give consistent scores.

Extraneous noise not only may affect the listener but makes it difficult also for the examiner to maintain a constant level of loudness on all occasions. The habit of adjusting the loudness level of the voice to meet changing conditions of noise is usually quite unconscious.

Preliminary practice and instructions.

Preliminary practice is given through both hearing and lipreading combined for both vowel and consonant parts of the test. The examiner says, "Tell me what I say?" The practice is continued until the patient shows by the accuracy and manner of his response that he fully understands what is needed.

Tests without lipreading, (*a*) without and (*b*) with hearing-aids follow. In tests with a hearing-aid the level of loudness at which speech is most intelligible to the patient (and therefore the point at which it is best to set the volume control of the aid) should be found by actual experiment. The patient is often only qualified to judge it for himself after considerable experience.

Tests with the unaided ear should be made at a distance of several feet from walls or similar surfaces liable to cause reflection.

The following is a sample record sheet used in the clinic attached to the Department of Education of the Deaf. No series of vowels or consonants should be repeated more than once with any one listener.

The numbers are called in pairs, e.g. the examiner says "eight, four" and the patient repeats what he believes he has heard. There should be a pause of half a second between each number in each pair, and of not more than 4 seconds between each pair, to allow the patient to reply and the examiner to mark the record sheet. The pronunciation of vowels is:

ah	as in	bark	oo	as in	two
er	,,	turn	aw	,,	lawn
ay	,,	hay	oa	,,	road
ow	,,	cow	ee	,,	see
oy	,,	boy	ie	,,	tie.

Allow 3 seconds pause between each monosyllable in the vowel and consonant sections.

It is essential to establish in the patient's mind an attitude of confidence and willingness to co-operate. It may be impossible to save him from a consciousness of mistakes, but it should be made

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clear to him, if necessary, that such tests are not always carried out without mistakes even by listeners with normal hearing and that their occurrence must not cause him any anxiety.

Tests with Hearing-Aids. (Time : 20-30 minutes.)

Examiner :

Ear tested :

(*a*) Called Number Test. (Examiner strikes out numbers incorrectly heard.)

One or more columns to be used at each test.

Index letter.					
	84 65 13 22 16 58 32 44 53 99	28 35 64 25 19 24 56 48 93 31	41 84 23 66 52 58 92 35 39 14	63 92 48 15 59 24 61 85 24 33	25 43 86 93 45 16 13 92 58 49
Total					

Index letters : U : Unaided ear
A : Electrical aid, No. 1
B : „ „ No. 2
C : „ „ No. 3
S : Speaking-tube.

(*b*) Vowel Test. (Examiner strikes out vowels incorrectly heard.)

One or more columns to be used at each test.

Index letter.					
	ah er ay ow oy oo aw oa ee ie	aw ee ow ay oo ie oa er ah oy	ie ay oo ah oa er ow aw oy ee	ay oo ah ee er oa ow oy aw ie	oo ah aw oa ie ay ow er ee oy
Total					

(*c*) Consonant Test. (Examiner strikes out syllables of which consonant is incorrectly heard.)

One or more columns to be used at each test.

Index letter					
	baw	daw	shaw	law	saw
	vaw	saw	baw	gaw	thaw
	gaw	vaw	maw	saw	maw
	law	shaw	law	daw	shaw
	shaw	jaw	vaw	baw	daw
	maw	maw	gaw	jaw	baw
	jaw	law	daw	maw	jaw
	daw	gaw	saw	vaw	gaw
	saw	thaw	jaw	thaw	law
	thaw	baw	thaw	shaw	vaw
Total					

Aid Recommended..

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Advice given about use.................................

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Remarks :

INDEX OF SUBJECTS.

INDEX OF AUTHORS.

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